The Journal of ENGINEERING EDUCATION

March, 1958 ***Table of Contents*** **Vol. 48, No. 7**

Do You Know 487

National Support for Basic Research and Teaching Programs Urged by CDEF 490

The Nation *Must* Solve Its Engineering Faculty Shortage 491

EJC–EMC Manpower Recommendations 494

Articles

Reorientation in Engineering Education — L. V. Bewley 497

Faculty Compensation Policies and Practices — Ross J. Martin 508

Intellectual and Nonintellectual Factors Involved in Predicting Engineering Success — William K. LeBold 514

The Growth and Development of the Engineer in Industry — T. J. Carron 520

Engineering Sciences—Still Another Look — Gene M. Norby, Robert N. Faiman 527

Engineering and Management Decisions in the Port of New York Authority — Austin J. Tobin 530

Closed-Circuit Television Instruction in Mechanical Engineering — W. F. Seibert 538

General Education and the Law of Increasing Entropy — Sterling P. Olmsted 545

What Can You Tell a Young Engineer About Ethics? — Harold A. Bolz 551

A Plan for Integrating Courses — David W. Lewis 559

The Rejuvenation of a Materials Testing Laboratory — C. W. Richards 562

An Engineering Teacher Looks at the Humanities Program — Fred Landis 568

A Humanities Teacher Looks at Engineering Education — Thomas F. Green 572

Departments

New Members of ASEE 577

Teaching Positions Available 580

Ballot for ASEE Officers, 1958–1959 581

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Notes

New ECRC Research Review	489	Transactions of the Chemical Engineering Division	550
ASEE Lapel Emblems	489	College Notes	558
College Notes	513	Statement of ABC Conference on Drawing Practice	567
To Study College Presidency	526	Heat Power News and Views	572
Publications Received	529	William Ogden Wiley	576
Florida Doctoral Program	537	Air Pollution and Its Control	579
New Home for Brooklyn Technical School	544		

ASAE GRADUATE TEACHING SEMINAR

The *Proceedings of the Agricultural Engineering Graduate Teaching Seminar* have recently been published by the American Society of Agricultural Engineers, Saint Joseph, Michigan.

This seminar was conducted at Michigan State University in June, 1957, by the ASAE Committee on Graduate Instruction and the Education and Research Division of the ASAE with the Agricultural Engineering Division of ASEE cooperating. It was held in conjunction with the Golden Anniversary of the ASAE. The program and all papers presented at the meetings are published in the *Proceedings*.

Vote for ASEE National Officers

(See Ballot, page 581)

DO YOU KNOW . . . .

► . . . . That the Annual Meeting will be held at the University of California in Berkeley on June 16–20?

► . . . . That Monday afternoon's General Session of the Annual Meeting will be highlighted by the report on the Technical Institute Survey? The remainder of the program will be short reports on two or three other special studies financed by outside agencies. This should be the best Monday afternoon program in many years! To a large extent engineering teachers and colleges of engineering believe they can ignore the area of technical institute education and leave it for others to think about. Is this the correct attitude? Here will be your chance to find out what the status of technical institute education is at the present time.

► . . . . That the speaker for the joint ECAC and ECRC banquet on Tuesday night of the Annual Meeting will be Dr. Simon Ramo, President of the Space Technology Laboratories of the Ramo-Wooldridge Corporation? In that capacity he is "chief scientist" and has over-all technical supervision and weapons system responsibility for the USAF Ballistic Missile Program, including the intercontinental Atlas and Titan as well as the intermediate range Thor. The exact title of his paper has not been announced, but you can rest assured his remarks will be timely and pertinent.

► . . . . That in commenting on ASEE's recently published Salary Survey of engineering faculties, Mr. Frank H. Smith in his interesting column "On the Shelf," December 27 issue of Engineering, Ltd., started out with, "Comparative salaries of the United States are always interesting to those in this country who do not own Cadillacs or replace their refrigerators each year." I asked my dean about my Cadillac. Have each of you gotten yours?

► . . . . That there is an answer to "What Are the Young People Thinking?" It is found in the results of a survey of college undergraduate opinion made by the Educational Communications staff of the General Electric Company and reported in their Educational Relations Information Bulletin entitled "What Are the Young People Thinking?" Of particular interest to everyone involved in engineering teaching is the question, "It has been said that ideals are nice if you can afford them, and that life consists of a series of compromises. Listed below are a number of fields of work. In which do you think you would have to "conform" the least, and make the fewest concessions with your personal beliefs? (List in order, 1, 2, 3, etc.)—A. Politics, B. Government Service, C. Engineering, D. Retail Business, E. Big Business, F. Atomic Science, G. Labor Organization, H. College Teaching, I. Public-School Teaching, J. Law, K. Ministry, L. Advertising, M. Medicine." This question was answered by almost 2,000 undergraduates at twenty colleges and universities, five of which have engineering curricula. The total results indicate that students believe the calling that requires the least compromise with personal beliefs is *college teaching* and that *engineering* was in second place! Doesn't this give us a potent argument for interesting good students in taking graduate work and going into engineering teaching as a career? Copies of the report are available upon request from The Educational Relations and Corporate Support Service, Department 2-119, General Electric, Schenectady 5, New York.

► . . . . That 3,068,000 students enrolled in 1,890 colleges and universities last fall? This is 4.1 per cent over the total for the fall of 1956, 45 per cent above the total for the fall of 1951 (the year of lowest enrollment since World War II), and 25 per cent above the fall of 1949, the peak year for enrollment in the immediate post-war years. The 45 per cent increase since 1951 compares to about a 2 per cent increase in the number of persons 18 to 21 years old during the same periods. The number of college-age persons in the population won't start to climb steeply until the early 1960's. Nearly two-thirds of the current student body are men. Opening enrollments in liberal arts colleges gained 6.5 per cent over 1956; junior colleges, 6.2 per cent; teachers colleges, 6 per cent; technological schools, 3.4 per cent; universities, 2 per cent; theological and religious schools, 1 per cent. Publicly controlled institutions had a 5.9 per cent gain in number of students over the fall of 1956, while privately controlled schools had 1.8 per cent more; 58 per cent of the total college population were attending publicly controlled institutions. The figures came from the January 1958 issue of Higher Education, a publication of the U. S. Office of Education.

► . . . . That the National Academy of Sciences–National Research Council has established a new Office of Critical Tables? Its function is to take the lead in building cooperative, purposive relations among data compilation projects carried on in many places and to stimulate new projects where necessary. It hopes to maintain a broad continuing coverage of the needs for numerical data in the physical and engineering sciences, in a form that will be of maximum usefulness and accessibility to scientists and engineers everywhere. The work of the Office is to be guided by an executive committee of five, the chairman being Dr. A. V. Austin, Director of the National Bureau of Standards. There also is a Large Advisory Board on which ASEE is represented.

► . . . . That there now is a World-Wide Graduate Award Directory?" It is published by The Advancement and Placement Institute, Box 99E, Greenpoint Station, Brooklyn 22, N. Y. and sells for $2.00 per copy. This first annual Directory contains information about field of study, duration of awards, amount of stipend, number available, to whom and when to apply, etc. Over 350 Universities and Foundations in 45 states and 30 foreign countries cooperated by submitting information.

► . . . . That for the first time in history EJC is scheduling a meeting outside of New York City. Chicago will be the location of the first regional meeting and the Western Society of Engineers will act as host. The probable theme for the early May meeting is "The Engineer in 1975."

► . . . . That plans for the new United Engineering Center in New York City have been finalized? Many of you know this from other publications, but since questions are asked repetition may not be out of place. A 20-story tower is to be erected between 47th and 48th Streets fronting the United Nations' campus. The estimated cost is $10,000,000 and occupancy is planned for the fall of 1960. ASEE will not be among the sixteen national engineering societies having their headquarters in the building.

W. Leighton Collins
Secretary

NEW ECRC RESEARCH REVIEW

The 1957–1959 edition of the ECRC *Engineering College Research Review* is now available for distribution at $2.00 per copy. The volume covers, in 408 pages, investigations representing more than 100 million dollars and the efforts of over 15,000 faculty members, graduate assistants, and research engineers in 107 member institutions. It provides an exhaustive analysis and location guide for engineering and associated science research activities and capabilities in colleges and universities throughout the country. As such, the *Review* is a unique and necessary repeated-reference tool for both college and industry libraries, for placement of research contracts or inquiries, and for individual research workers and teams or groups.

For each institution, names of research administrative personnel are given, research policies or limitations are discussed briefly, and activities such as courses, conferences, and specific projects are listed by title. Numbers of personnel assigned to each project are added as an indication of scope.

As an aid for the administrator or worker seeking to locate activitiy in an area of concern to him, a full and carefully compiled subject index of more than 50 pages is supplied. This gives direct leads to the institutions and divisions concerned. A very useful level of subheading is maintained throughout.

Special features of this edition are a comprehensive history of the Engineering College Research Council, a statement of ECRC research policy, and a listing of the 107 member institutions and their representatives on the Council. An official ASEE contribution of the ECRC, the *Review* is edited by Professor Renato Contini of New York University. Copies, order blanks, and further information can be obtained from Professor Contini, ECRC Secretary, University Heights, New York 53.

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NATIONAL SUPPORT FOR BASIC RESEARCH AND TEACHING PROGRAMS URGED BY CDEF

A letter from the ASEE Committee on the Development of Engineering Faculties

December 17, 1957

Dr. James R. Killian, Jr.
Special Assistant to the President
for Science and Technology
Executive Office Building
Washington, D. C.

Dear Dr. Killian:

That the nation is facing a great oncoming tide of additional students in its colleges and universities during the next ten years is widely recognized. Hence we shall be critically short of college teachers, and this shortage will be especially acute in engineering where the competition of industry and government for the ablest college graduates is greatest.

Sensing the urgency being felt at the national level about this problem, the Committee on the Development of Engineering Faculties of the American Society of Engineering Education respectfully submits to you the accompanying statement and recommendations that it believes important in the national consideration of this problem.

The primary need is for more of our ablest recipients of bachelor's degrees in engineering to enroll in our full-time residential graduate schools because it is this source that chiefly produces our engineering faculties. Therefore adequate support of these students and of the augmented needs of these graduate schools is of the utmost importance.

Copies of this letter and its attachment are being sent to a number of other persons who are seriously concerned with this problem.

Sincerely yours,

Harold L. Hazen, Chairman
Committee on the Development
of Engineering Faculties

Copies to:
Secretary Folsom
Secretary McElroy
Admiral Strauss
Dr. A. T. Waterman
Dr. H. L. Bevis
Dr. W. L. Everitt
Dr. A. S. Adams

THE NATION *MUST* SOLVE ITS ENGINEERING FACULTY SHORTAGE

Recommendations of the Committee on the Development of Engineering Faculties of the American Society for Engineering Education *

Facts Bearing on the Problem

The most critical shortage affecting engineering education at the university level is, and will be for the next decade, the shortage of engineering teachers. Of secondary but critical importance is the deficiency in laboratory, classroom, and office space. These resources are insufficient for present enrollment and for those we expect. Therefore, unless and until these critical shortages are relieved, programs which aim primarily at increasing the supply of undergraduate engineering students beyond those now in sight are highly questionable. On the other hand, programs to support improvement of their high school preparation in English, Mathematics, Science, Language, and History are most important.

Engineering and Physical Science are expanding explosively in their demands for keen insight and a high level of educational attainment. The principal source of new teachers who can meet the needs of this scientifically based technology must come from the graduates of our *resident* graduate schools, particularly those who complete the doctorate. "Resident" work is emphasized because experience has shown that students who take graduate work on a part-time basis while employed in industry are almost never attracted to academic careers.

Engineering graduates find industrial life attractive or they would not have chosen engineering in the first place. Therefore, the problem of inducing an adequate portion of those with the best minds to enter teaching is particularly difficult in the field of engineering. The large salary differential in early years, when families are being established, has made the problem particularly critical at the present time.

Engineers and scientists with bachelor's degrees will not attend graduate school if they are solely dependent on their own or their families' resources. Therefore, the supply of resident students for engineering graduate schools depends upon support in the form of scholarships and assistantships. The principal sources of such support are the institutions themselves, the federal government, and, to a limited extent, industry. Currently, the major forms of federal support for engineering graduate work are:

(1) Research projects of the Department of Defense, particularly those of a basic nature

(2) Research projects of the Atomic Energy Commission

(3) Research projects of the National Science Foundation

(4) Fellowships of the National Science Foundation.

A research program is the most essential and costly component of advanced education leading to the doctorate. Modern technology requires laboratory facilities and instrumenta-

* This Proposal was drafted for the Committee by one of its members, Dr. W. L. Everitt, Dean of Engineering, University of Illinois.

tion which are fantastically expensive when compared with prewar standards. It is doubtful if more than a tiny trickle of adequately trained Ph.D.'s in engineering could be supplied by the educational institutions of the country if these institutions were dependent solely on their own resources. The importance of the basic research programs supported by the federal government is indicated by the fact that, as the funds for these programs leveled off, the number of Ph.D.'s graduating in engineering in the United States followed the same pattern, becoming practically constant for the past five years at about six hundred per annum.

Conclusions

The leaders in government should recognize that the support of basic research in engineering and the form in which it is offered are of the utmost importance to the nation. These factors will determine not only the level of research, but also the supply of individuals with the requisite background to educate engineers in an age when basic understanding of scientific principles must replace dependence on intuition and experience. From this same source must also be drawn the engineering and scientific leaders in industry and government.

It seems evident the needs of the future call for expansion of the support of basic research in engineering. But such expansion cannot be undertaken by universities unless the *true* cost of this expansion is supported by the sponsors. These same universities are being called upon to take care of an undergraduate student population increasing because of the greater birth rate and an enhanced evaluation of the worth of higher education.

The true costs of an expanded basic research program include the support of the faculty salaries needed, not only to direct the projects, but also to guide and instruct the graduate students involved. Expansion also introduces increased costs for buildings to house the laboratories and offices required by an enlarged faculty and graduate student body. It is no longer possible to obtain such space by diverting existing classrooms and instructional laboratories and crowding offices as has been done repeatedly in the past. The current allowances for indirect costs should also be reevaluated, since there is serious question as to the adequacy of present allowances. Furthermore, it should be recognized that costs increase if programs are unstable and frequent renegotiation is necessary or periods of nonsupport are recurring.

Program Recommendations

Part I

It is recommended that federal agencies supporting basic research in engineering should:

(1) Increase the number of basic research contracts with the universities.

(2) Encourage the use of graduate students on basic research projects, recognizing that an important return to all agencies of the government is the development of technical competence, as well as the actual research accomplished.

(3) In each project, support the portion of the faculty salary used to direct the project and give guidance and instruction to the graduate students involved.

(4) Provide longer-term contracts of the order of five years so that areas of competence in each educational institution may be developed and supported without straining the educational resources through contract instability.

(5) Pay adequate indirect costs so that other resources of the educational institution are not tapped to support federal projects.

(6) Provide means for the construction or enlargement of buildings required for these research projects. For example, a possible means would be federal loans and provision for their retirement from contract funds.

Part II

Further steps are also needed to guide more graduate students into teaching.

All engineering educators agree that teaching is itself a most effective means for educating the teacher; therefore, teaching experience should be included in a well-rounded advanced education program. When one is called upon to explain a difficult concept to others, he is really driven to deepening his own grasp of the fundamentals. Furthermore, experience has shown that an appreciable proportion of those who have an opportunity or obligation to teach engineering are attracted to it as a career. Those who do not have such an experience seldom choose an academic life. Therefore, every qualified engineering graduate student should be given not only an opportunity but an obligation to assist his university in the teaching program.

It is proposed, therefore, that:

(1) Winners of National Science Foundation Fellowships in the first or second year be granted an additional but separate stipend if they are given limited teaching assignments of the order of quarter-time at the university of their choice. It is believed such a limited teaching experience could be undertaken without a reduction in academic load, and might whet the student's appetite for an academic career.

(2) National Science Fellowship-Teaching Assistantships be set up with universities on a matching basis, the Fellowship being a grant to support the student for his part-time studies—the Assistantship to be paid by the institution for the time devoted to teaching. In this way, earnings of young engineers in graduate school who are teaching could be made more comparable with industrial salaries.

(3) Those who receive honorary mention in the competition for National Science Scholarships be given a grant of say, $500, if they accept teaching assistantships at a university.

(4) The number of National Science Scholarships for the first year of graduate work in engineering be increased substantially.

The complete program recommended provides for support of the expensive research area of graduate programs through an evolutionary but not revolutionary change in present federal policies.

The development of this plan would allow more engineering students to follow a program of the following general character:

One year of study leading to the Master's degree or equivalent with possibly a partial experience in teaching.

Two years of combined teaching and course work on Fellowship-Teaching Assistantships.

Two years of basic research work, which would in most cases complete the requirements for the doctorate.

The proposed program would increase the critically inadequate supply of well-educated engineers and an appreciable proportion should become interested in teaching careers.

EJC-EMC MANPOWER RECOMMENDATIONS

Support ASEE-CDEF Program

Engineers Joint Council

Engineering Manpower Commission

December 17, 1957

Dr. James R. Killian, Jr.
Special Assistant to the President
for Science and Technology
The White House
Washington, D. C.

Dear Dr. Killian:

On behalf of the Engineering Manpower Commission of Engineers Joint Council and the Scientific Manpower Commission, we wish to extend our congratulations and best wishes to you on your appointment as Special Assistant to the President for Science and Technology.

For many years the Commissions have been struggling with the problems of motivation, utilization, and recognition of engineers and scientists—problems recently projected into a position of national importance and attention by international events. In the light of these events, the Engineering Manpower Commission, at its meeting of December 12, gave careful attention and consideration to the current situation and more particularly to the programs the Federal Government is developing to meet this situation, insofar as they are now publicly revealed. While we realize that this programming is still far from firm, you may wish to consider our thoughts on developments thus far discernible.

We believe that the technical manpower issues and related educational problems can best be understood when analyzed separately in terms of the short and the long range aspects, each having different implications and requiring dissimilar treatment. Thus far, most of the governmental activity as revealed to the public, has stressed solutions to essentially long range problems—those related to education and basic research.

We concur—indeed, insist—that there are extremely important problems in these areas that demand attention. Nonetheless, we find little enthusiasm in the engineering community for the launching of a Federal undergraduate scholarship program. Industrial and private attention to financial support of higher education is at an all time high and with the increased participation of these sources it would indeed be regrettable to discourage them and reverse this trend. This will inevitably occur should the Federal Government start allocating funds for the same purposes. As you know so well, the large problem of engineering and scientific education today is not one of undergraduate student dearth. Indeed, there is great concern for the preservation of quality in engineer-

ing education as it attempts to meet the great student demands that exist now and that lie ahead with depleted faculties and overburdened facilities. These are some of the conclusions that clearly emerged at the Conference on Higher Education, Science, and Technology, held in Chicago on October 31–November 2, 1957, and jointly sponsored by the National Science Foundation, the National Research Council, the Scientific Manpower Commission and Engineers Joint Council, including the American Society for Engineering Education. In this regard, we strongly support and endorse the important recommendations recently made by the Committee on the Development of Engineering Faculties of the American Society for Engineering Education, a constituent Society of Engineers Joint Council. We would also favor programs directed toward increasing the quality of graduate studies in engineering and science.

Support CDEF Program

We fear that these long range considerations may be diverting attention from the short range problems and actions that could have more immediate results and which, therefore, should take precedence.

As you know, the general technological momentum in the United States has slowed materially in the past few months. Indeed, the announcement of the Soviet advances came at a time when we were trying to assess the effect of this slowing, not only in terms of individual displacement, but on arranged research and development teams in the universities and in industry throughout the country. There is, in other words, a measurable softening in the demand for technical personnel at a time when programs are proposed to achieve increments in its work force. It seems clear that, given the proper challenge, American technology could impressively increase its obligation and output, without significant quantitative additions to its numbers. Happily, this appears to be particularly true in the very areas most intimately associated with research and development of most advanced weaponry.

It is equally clear, however, that any significant increase in defense programming to meet the new challenge will again produce additional manpower needs. Should this indeed occur, important immediate measures should be considered—actions by industry, but primarily by government. We have long stressed the manpower waste caused by improper utilization of technical personnel, and there is evidence that much has been accomplished to improve this situation in the past few years. More needs to be done and it is particularly appropriate that the President's Committee on Scientists and Engineers is sponsoring utilization conferences throughout the country. Encouraging progress will undoubtedly result from these programs and others that need expanded effort. As industrial utilization improves, however, it behooves us to note that during the past few years we have had another great manpower waste, the result of substantially outmoded military manpower procurement policies.

Indeed, we may be in danger of overlooking this fact and fail to avail ourselves of a largely unused resource of technical manpower, which could be quickly made available to government, industry, and education. These young engineers and scientists—many with impressive educational and professional backgrounds—are still being diverted from technical pursuits by military procurement laws and regulations.

We do believe, of course, that the military should have in the uniformed services all the engineers and scientists needed as such, but our country cannot, we believe, continue to waste their talents on non-technical duties. As a beginning in remedying this situation, and as additional manpower needs develop, we would strongly recommend:

1. The suspension of induction for military service of engineers and scientists and certain other groups having critical occupations. All things considered, it is our conviction that to expect the military to achieve a satisfactory level of utilization for engineers and scientists in an enlisted capacity places too great a burden on military personnel administrative process.
2. The release from the military of engineers and scientists not being utilized in their professional capacities, if they request such release.
3. The revision of ROTC assignment procedures to give priority for brief active duty training periods to engineering and scientific graduates after selections have been made to meet the military needs for technical billets and overriding non-technical military specialties. It is anticipated that the release of enlisted engineers and scientists might increase military needs for ROTC graduates in technical billets. This, we believe, is all to the good.
4. Review of military retirement procedures to insure that the technical competence of experienced but relatively youthful officers is not lost to the military through premature and forced retirement in accordance with regulations having little pertinence to current and future Armed Forces technical requirements.
5. The development of a truly Professional Service for career engineers and scientists in the uniformed military services. It seems to us that this was a notable omission in the Cordiner Committee recommendations.

The implementation of these recommendations would not only release several thousand young technologists for work in their fields, but would have salutary effects on the morale of those involved.

In essence, we maintain that the country has now the engineers and scientists necessary to accomplish the immediate task before us and we need only to develop and implement policies and plans to properly administer their talents. While thus reorganizing to meet current needs we can weigh, with more deliberation, the longer range problems with greater assurance that change will really produce improvement.

We, of course, stand ready to elaborate on any of these considerations or to be of any assistance to you in your new tasks, and we trust you will feel free to call on us at your convenience.

Sincerely yours,

G. E. ARNOLD, *Chairman*
Engineering Manpower Commission of Engineers Joint Council

H. A. MEYERHOFF, *Executive Director*
Scientific Manpower Commission

REORIENTATION IN ENGINEERING EDUCATION

L. V. BEWLEY

Dean, College of Engineering, Lehigh University
Bethlehem, Pennsylvania

The rapidly growing demand for more and more engineering graduates, coupled with the increasing difficulty of securing and retaining competent teaching staffs under conditions of insufficient budgets, together with the need for greatly expanded facilities, necessitates an "agonizing reappraisal" of existing methods of engineering education, with a view towards markedly more efficient and economical use of teachers, equipment and space. Ways must be found to make better use of teaching talent, improve the utilization of laboratories and equipment, increase the effectiveness of available space, and reduce the cost of administration.

To this end,worthwhile possibilities present themselves when the entire field of engineering is closely examined to determine the overlap between its different branches, and the aspects which are common to all.

Suppose that all existing and traditional classifications in engineering (C.E., M.E., E.E., I.E., Ch.E., E.M., Met.E., etc.) were to be wiped out and forgotten, and we were given the task of drawing up a new and completely rational classification, uninhibited by custom or practice, and bound only by the following principles:

1. Those engineering activities which are closely allied by theory and practice, and which depend upon the same background, basic training, and disciplines, shall constitute a division of engineering (a field of specialization).

2. A division of engineering shall be of sufficient scope and depth to engage the full capacity and ability of those trained in that field.

3. A division of engineering shall not be so broad or involved as to prevent thorough and adequate training of competent specialists.

4. A division of engineering shall not include widely divergent subject matter, or unrelated activities (like the present sanitary and structural options in C.E.).

5. The number of divisions shall be limited to the fewest which are necessary and feasible, and common features, rather than minor differences, shall determine the establishment of a division.

What, then, would the new divisions of engineering be, and how can they best be organized within an engineering college?

Even if the practicing divisions of engineering kept their present designations and numerous specialized subdivisions, what organizational changes for teaching are suggested by recognition of the actual compartmentization in the practice of engineering?

It is the purpose of this paper to explore these questions and to offer for consideration, a plan for the teaching of engineering which is a radical departure from the existing pattern.

Table I lists the major divisions and principal subdivisions (the college options) of engineering, together with the basic technical requirements in each division. The table includes only the seven major fields, though more than 140 different "kinds" of engineering are said to be taught! Note, among these seven fields, the obvious redundancies and repetitions,

TABLE I

Engineering Curricula	Technical Requirements
1. Civil Engineering (C.E.)	
a. Structural design (bridges, buildings, reinforced concrete, dams, foundations)	Mechanics (statics, dynamics, kinematics, strength of materials, elasticity, plasticity, analytic dynamics, vibration theory)
b. Hydraulics (water power developments, machinery)	Fluid mechanics, mechanics, soil mechanics
c. Sanitary (water supply, sewage systems)	Fluid mechanics, chemistry
d. General Engineering & Construction (surverying, highways, railroads, airports, terminals, harbors, docks, subways, erection of structions, excavations, welding, estimates & evaluations, specifications)	Drafting, surveying, materials handling, construction methods, engineering economics, principles of management
2. Mechanical Engineering (M.E.)	
a. Machine design	Mechanics
b. Heat power (steam generators, engines, turbines, internal combustion engines, gas turbines and jet engines, compressors, pumps, power plants)	Thermodynamics, heat transfer, fluid mechanics, mechanics, fuel technology
c. Air conditioning, refrigeration, heating and ventilating	Same as in 2b
d. Instrumentation	Same as in 2b
e. Aerodynamics	Same as in 2a and 2b
3. Electrical Engineering (E.E.)	
a. Power (generation, transmission, distribution, control, utilization of energy)	Circuits, fields, measurements, transients, d.c. and a.c. machines, transmission lines, symmetrical components, system stability, surge phenomena
b. Electronics (industrial control, instrumentation, computers, servo-mechanisms)	Vacuum tubes, electronic circuits, servomechanisms, computer circuits
c. Communications (wire, radio, radar, television)	Vacuum tubes, electronic circuits, wire communication, radio theory, network theory
4. Metallurgical Engineering (Met.E.)	
a. Physical metallurgy (research on the physical and structural properties of metals and alloys)	Analytical and physical chemistry, physical metallurgy, metallography, mechanics, heat transfer
b. Metallurgical processes (smelting, roasting, refining, rolling, casting, forging, heat treatment, annealing, hardening, welding, electrolytic processes, machining, fabrication)	Metallurgy of iron and steel, non-ferrous metallurgy, electrochemistry and electrometallurgy, ore dressing
5. Mining Engineering (E.M.)	
a. Engineering geophysics (properties of rocks and minerals, methods, instruments)	Geology, electromagnetic theory, electronics
b. Mining methods (prospecting, tunnels and shafts, mechanization, ventilation, haulage and hoisting, pumping, administration)	Surveying, mechanics, hydraulics, geology, materials handling, construction methods, engineering economics, principles of management
c. Processing (crushing, classifying, concentrating, flow sheets)	Process metallurgy, fuel technology

TABLE I—*Continued*

Engineering Curricula	Technical Requirements
6. CHEMICAL ENGINEERING (Ch.E.) Unit processes (reactions, heat and energy balances, fluid flow, combustion, vaporization, condensation, solubility, crystallization, diffusion, distillation, absorption, drying, extraction, separation, classification, filtration, instrumentation, plant layout, equipment, administration)	Chemistry, thermodynamics, heat transfer, fluid mechanics, fuel technology, materials handling, engineering economics, principles of management
7. INDUSTRIAL ENGINEERING (I.E.) Plant administration, production control, quality control, product engineering, work simplification, wage and salary administration, personnel administration, industrial relations	Basic engineering, materials handling, statistical analysis, economics, engineering economy, accounting, cost analysis, finance, business methods, psychology, labor relations, principles of management

and consider the extravagant duplication of equipment, instruments, and apparatus, and the wanton waste of space apparent in this grouping of engineering studies.

Too many unnatural weddings have been performed in pairing the present-day subdivisions of engineering. Teaching could be greatly simplified and its efficiency and effectiveness increased by a regrouping that joined more natural partners. Ultimate bending of any curriculum in the direction of its specific applications is of course justified, but this bending need not begin until later. The common stem of basic engineering studies should be preserved as long as possible. For example, the differences in the type of thermodynamics taught in mechanical engineering, chemistry, and physics are not so vital that they need be emphasized until the student's basic knowledge of thermodynamics is utilized in advanced courses dealing with specific applications.

Growth and Subdivision

A comparison of the various curricula in colleges of engineering, presented in Table II, discloses that approximately fifty per cent (50%) of the course content of all curricula is identical, that an additional fifteen

TABLE II

THE COMMON STEM OF THE DIFFERENT CURRICULA IN A TYPICAL ENGINEERING COLLEGE REQUIRING 144 CREDIT HOURS FOR GRADUATION

	Credit Hours	Per Cent
Identical for all curricula:		
Mathematics (through calculus)	12	
Physics (mechanics, heat, light, sound, electricity and magnetism)	12	
Chemistry (general)	8	
Engineering drawing	3	
Humanistic-Social (English, history, economics, electives)	30	
Military science	8	
	73	51%
Common for *most* of the curricula:		
Mechanics (statics, dynamics, strength of materials, fluid mechanics)	14	
Electric circuits, machines, and electronics	5	
Heat engines or Thermodynamics	4	
Engineering materials	3	
	26	18%
Additional similar material in divisions of specialization: (Methods of analysis, techniques, general principles, and duplicate coverage—estimated)	14	10%
Total Essentially Identical Material	113	79%

per cent (15%) is identical in most curricula, and still further, that ten per cent (10%) is essentially equivalent in that courses taught by different departments overlap and duplicate material. Probably at least two-thirds of the actual subject matter studied by undergraduate engineering students is the same, regardless of curricula.

A further observation is that departments tend to become independent and autonomous, either because faculties feel that only they can give the proper slant and emphasis to subjects studied by their students, or purely as a means of "empire building." Thus, *mechanics* is taught in various forms by the physics, mechanics, mechanical engineering, civil engineering, and mathematics departments. *Thermodynamics* is taught by the physics, mechanical engineering, chemical engineering, and chemistry departments. Some part of *electricity* is taught by the physics, electrical engineering, chemistry, metallurgical, and geophysics departments. And practically identical aspects of *materials handling* and *processing* are taught by the chemical engineering, mining, metallurgical, and civil engineering departments. Some engineering departments even endeavor to teach their own brand of mathematics!

Thus the unnatural and irrational subdivision of engineering into its existing branches and present-day compartmentization greatly complicates the situation and leads to a redundant and uneconomical educational process. This has come about partially as a result of the haphazard growth of engineering over the years. The developments and trends in the subdivision of engineering are traced in Figure 1.

The technical aspects of engineering derive from the physical sciences as applied to design and construction. Originally there were only two recognized branches of engineering, military and civil. Industrialization and the growing importance of the machine compelled civil engineering to break up into civil, mechanical, and mining engineering. The evolution

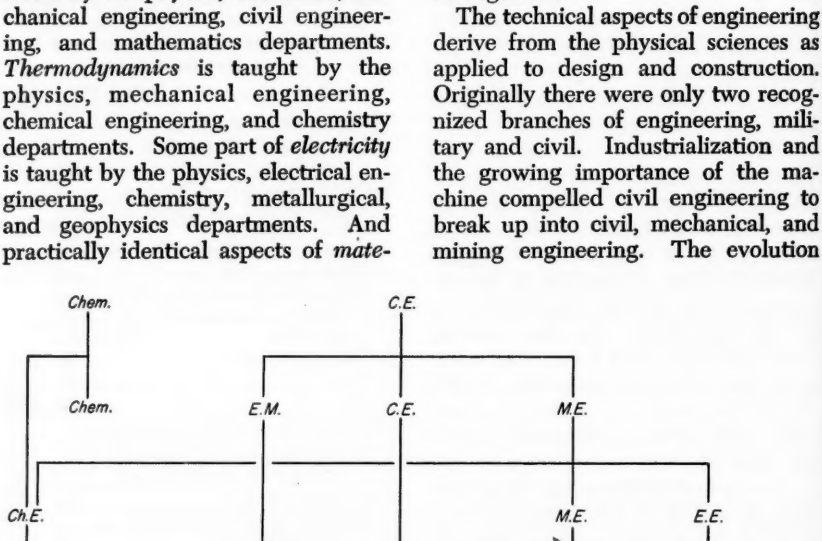

FIG. 1. Trends in the subdivision and specialization of engineering.

of electrical machines and devices soon created electrical engineering, more or less as an off-shoot of mechanical engineering. Chemical engineering was born as applied chemistry with a mechanical engineering flavor.

Later, as the scope of the parent engineering branches expanded and became bulky, mechanical engineering began to split into mechanical, industrial, and aeronautical engineering; mining engineering separated into mining and metallurgical engineering and engineering geophysics. About the same time, ceramic and petroleum engineering became the children of chemical and mining engineering. In the meantime, a trend developed to separate mechanics as an independent branch of engineering.

Now we seem to be on the threshold of further subdivision and specialization. New independent branches of engineering are being suggested and continually spring up here and there —textile engineering, sanitary engineering, architectural engineering, to name only a few. Perhaps in the near future electrical engineering will formally disassociate into power, electronics, and communications.

Instructional Service Departments

Regardless of the extent of specialization in the *practice* of engineering, there is no question but that greater unity and simplification could be achieved in the *teaching* of engineering if engineering departments were organized as *service departments* along the lines indicated in Figure 2. This plan requires six (6) major instructional departments of engineering:

I. Design
II. Power
III. Electrical
IV. Chemical and Physical Properties of Materials
V. Processing and Manufacturing
VI. General Engineering and Construction

Each department would offer courses required by several of the engineering curricula described in Table I, but no department would duplicate the content of courses offered in other departments. Students in any division of engineering, would receive instruction from several, perhaps all, departments.

Figure 2 illustrates the relationships between the proposed instructional departments and the divisions of engineering which have a paramount interest in the subjects taught by any department. Note that the Department of Design offers courses in machine design which are of paramount interest only to mechanical engineers. Mechanics courses, in this same department, are of paramount interest to both mechanical and civil engineers. Other subjects, like fuel technology offered in the Department of Chemical and Physical Properties, are of paramount interest to as many as five divisions of engineering. Courses in each department are of course open, and sometimes required, for students in all divisions.

As can be seen, all courses utilizing the same basic principles and fundamental studies are consolidated into single departments where like subject matter can be integrated, coordinated, administered and taught by the best available specialists on each subject. In the Department of Design, for instance, it is immaterial whether instructors are civil or mechanical engineers. The important thing is that the *sameness* of the subject matter is recognized and the advantages of unification are obtained. Not least among these advantages are the considerable economies effected by avoidance of duplication in teaching staff

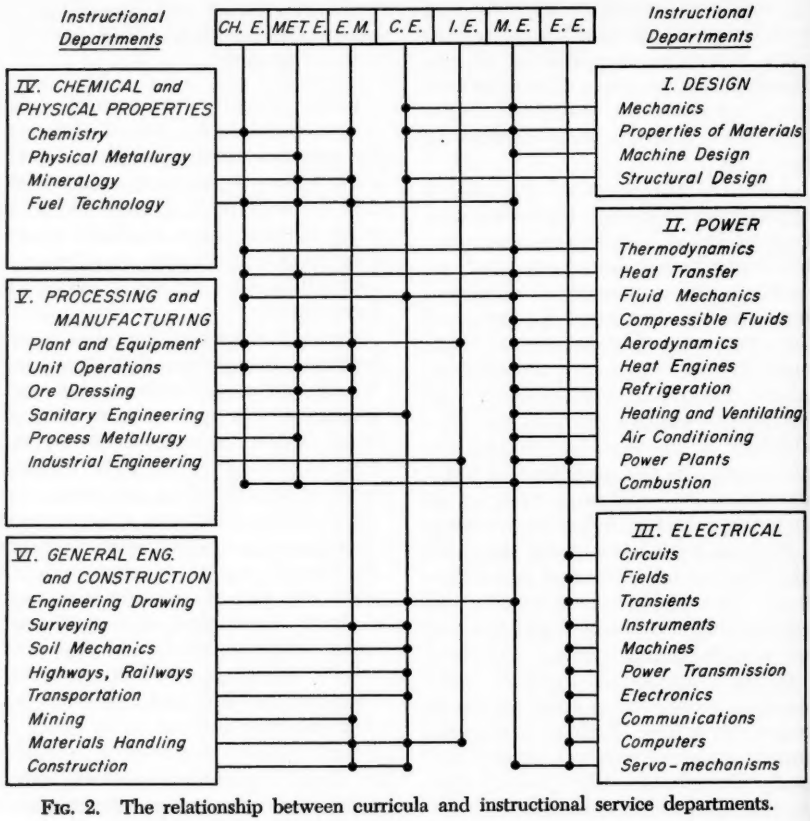

FIG. 2. The relationship between curricula and instructional service departments.

and laboratory equipment, and the ease of departmental management that results from removing the wide diversity of demands now placed upon department heads. Figure 2 also shows all subjects which have to do with *heat* and *fluid flow* consolidated into a single autonomous Power Engineering Department. Thermodynamics and fluid flow are inseparable and should be treated so. Chemists and chemical engineers, as well as mechanical engineers, would receive their basic instruction in thermodynamics, heat transfer, and similar subjects in this department.

Bernouilli's theorem in hydraulics, the steady flow equation in engineering thermodynamics, and the energy balance equation of chemical thermodynamics, are of identical nature, but of an increasing degree of generality. The study of steam flow through the blades and nozzles of a steam turbine, or of air flow around an air foil, or of water in a hydraulic turbine, entail the same procedures and mathematical disciplines. The cavitation problem in a water propeller is essentially the same problem in the blades of a steam turbine. The efficiencies of modern steam turbines did not begin to approach their present day levels until after many of the results of aerodynamical research were applied. Why, then, teach these aspects of the

same phenomena in different departments?

The plan suggests the concentration of all electrical subjects within a single Electrical Department. One usually finds electrical measurements taught in the physics department; electrical instrumentation taught in chemistry and geophysics; and electrolytic processes taught in chemistry, chemical engineering, and metallurgy. There is even an inclination to set up electrical instrumentation courses in mechanical engineering.

If there is to be any subdivision in electrical engineering, it would be more rational to split it into a power branch associated with, or a part of, the Power Engineering department; and an electronics and instruments department which would include all the rest. After all, the well qualified engineer in the power field should have a sound understanding of the steam, hydro, and electrical features of modern generating stations. But it is much easier to teach electrical power as one aspect of electromagnetic phenomena, along with all the other electrical subjects, than as a separate discipline.

There are a number of subjects of primary interest to one or more branches of engineering which are grouped together in Figure 2 under Chemical and Physical Properties. These include the courses in analytical chemistry taken by chemical, metallurgical, and mining engineers; other chemical courses taken by the chemical and sanitary engineers; physical metallurgy, assaying, fuel technology, crystallography, metallography, theory of solids, and others. None of these subjects are so far divorced from *chemistry* and *physics* that their teaching in a single department would present anything unusual.

Engineering is an alliance of *theory* (from mathematics, physics, and chemistry) and *practice*. The latter developed through the mechanical arts, and will always constitute a respectable part of engineering. The trade schools of this country and the technical institutes of Europe are mostly concerned with this aspect of engineering. Some engineering colleges devote a considerable part of their time and facilities to it. It would seem highly desirable to concentrate such training in a single department of General Engineering and Construction.

This department would be responsible for the teaching of such subjects as: mechanical drawing, surveying, transportation engineering, excavations, construction methods, and materials handling. Most of its courses would be designed to meet the needs of civil and mining engineers. Its offerings should prove very attractive to that type of student who is allergic to mathematics and higher theory, but who possesses reasonable practical sense and shows promise for a career in construction engineering. Such a department would offer a proper haven for the student who cannot hope to graduate in a "professional-scientific" curriculum, but will do well in general engineering.

The methods and management procedures employed in the manufacturing or processing of most products have much in common, whether it be in the chemical, mineral, or fabrication industries. For example, crushing, coarse and fine grinding, screening, classifying, filtering, thickening, decantation, settling, roasting, and other processes are to be found in ore dressing and chemical processing plants. The principles of plant layout and operation, of production and quality control, of work simplification, of valuation and appraisals, are not unique to any one industry or branch of engineering, but generally applica-

ble to all. It would appear logical, therefore, to consolidate the teaching of all such closely related subjects in a single department of Processing and Manufacturing.

Elementary Physics?

A question which at once presents itself is whether mechanics, heat, and electricity and magnetism should continue to be taught by the physics department, or be transferred to the corresponding engineering department? The great advantage of continuing the first elementary general treatment under physics is the opportunity thus provided to demonstrate the unity and common factors of all branches of physical science. On the other hand, the advantages of teaching every aspect of a subject under one department are provided by complete integration of that single subject from its most elementary to its most advanced stages.

The engineering student usually gains his first insight into physical principles from his general course in physics. Thereafter, as an undergraduate, he pursues matters in the engineering departments. But should he go on with graduate work, particularly at the doctoral level, he will find himself returning to the physics department. Ultimately there is very little difference between the ideas, procedures, mathematical requirements, and concepts to be found in dynamics, elasticity, heat, electricity, magnetism, light, or sound—they tend to coalesce. Actually, although it would never be recognized by the undergraduate, the theory of electricity is merely an adaptation of mechanics. In a sense, the whole of technical engineering may be thought of as filling the void between elementary and advanced physics, with tentacles deeply rooted in both these buttresses.

The modern trend is for engineering to take over more and more of the field of physics, while physics in turn explores ahead. Thus, most of classical physics has already joined the everyday working tools of advanced engineering. Moreover, engineering is pressing close on the heels of modern physics in seeking ways to apply new ideas to useful purposes. So there exists an intimate and essential liaison and alliance between engineering and physics, which must be preserved and fostered to the utmost.

Physics and engineering should augment and supplement, but not supplant, one another. The dividing line is often indistinct, or even artificial, but not of great importance. The writer inclines to the view that the time has come to relieve physics of elementary mechanics, heat, electricity and magnetism, and to place the teaching of these subjects under the corresponding engineering department; thereby consolidating efforts and relieving physics for new exploration.

Organization and Administration

While professional engineering practice, as well as engineering teaching, needs reclassification, it will take many years to accomplish a transition. But there is no reason why a bold college of engineering could not immediately reorganize along functional lines for purely instructional purposes. Such a college would graduate engineers fully qualified to enter present-day professional ranks. The conventional *curricula* could be retained, but there need be no corresponding *departments.* Training in each curriculum would be provided by the six instructional service departments.

Curricula directors as well as *service department heads* would be required, but usually the same man could perform both functions. The curricula directors would have very

few executive or administrative duties to perform (setting up the curriculum, rostering students, and keeping records) and would therefore be available as full-time instructors or researchers.

The administration of such a college of engineering would require a tight rein and close supervision. A dean of real competence, *familiar with all branches of engineering*, would be needed. The dean's office would furnish stenographic and clerical service for the curricula directors, and would be the office of record for all curricula. Proposals for changes in curricula would originate with the various curricula directors, and be approved by appropriate committees. Requests for new equipment would originate with the service department heads upon recommendation of the curricula directors. Changes in textbooks, laboratory experiments, and teaching methods would be a joint responsibility of curricula directors, department heads, and instructors in the courses involved.

Physical Layout of Plant

The envisaged six natural divisions of engineering suggest a several-storied building in the form of a hexagon with a spoke from the center of each side terminating on the common hub, as shown in Figure 3A. Each side would house one of the six divisions, and the corresponding spoke, the associated laboratories of that division. The central hub would contain the administrative offices, the common carpenter and machine shops, the stenographic and clerical pool, photographic dark rooms, and other common facilities. With this arrangement the common shops, pools and facilities would be equally available to all departments and laboratories, and the old argument in favor of separate and independent departmental

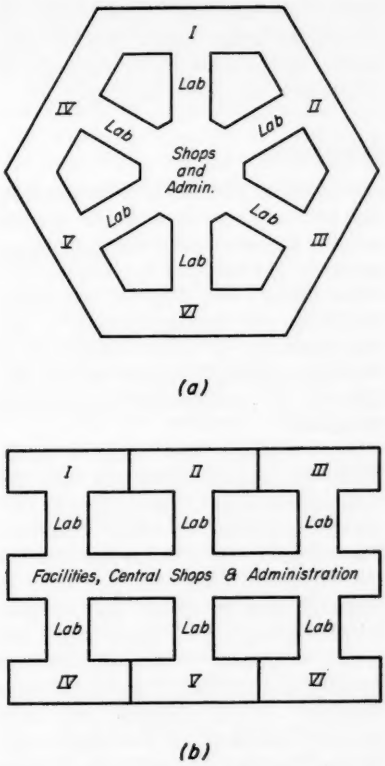

FIG. 3. Proposed physical layout of plant.

shops would have no basis. The opportunities for economy of equipment and technicians are very great with this setup.

The arrangement lends itself to expansion, either by placing additional buildings parallel to the sides of the hexagon or by adding floors. Also, service departments such as mathematics, physics, English, etc., could be housed in parallel buildings as a matter of convenience and symmetry.

An almost equally good arrangement, permitting centralization of common facilities, would be a double-ladder plan in which the shops and other common facilities would occupy the center aisle, with Divisions I, II,

III on one side and Divisions IV, V, VI on the other, each division connected to the center aisle through its laboratory, as shown in Figure 3B.

Advantages

A cardinal advantage of concentrating like subjects in a single department is the ease with which developments in one field can be diffused into other fields. For example, relaxation methods, now being applied so advantageously in civil engineering, could be high-lighted as a tool for the solution of mechanical engineering problems.

It is strange how long it takes, under the present setup, for new developments in one branch of engineering to penetrate to other branches. For instance, operational calculus, or the Laplacian transform, has been in constant and extensive use in electrical engineering for thirty years, but is only beginning to be used, and very timidly, in mechanical and civil engineering. Tensor analysis has been making headway in electrical engineering for twenty years, yet is practically unknown in other branches. What a shame that such powerful and useful tools and ideas cannot be disseminated more thoroughly and completely! We need an organization in engineering teaching that will do this —the present tightly compartmented departments fail to do so.

Another great advantage of the proposed instructional department organization is the opportunity provided to consolidate and effect great savings in laboratory equipment and operations. The utility factor of the average college laboratory is very low. Usually one finds a laboratory in operation during the afternoons only, and rarely at uniform capacity throughout the week. And, of course, it is dormant during the summer and holiday vacations. Furthermore, there is much duplication of equipment between different laboratories. Chemistry, metallurgy, and physics may all have expensive x-ray apparatus; chemical engineering and mining may have duplicate grinding equipment; and physics and electrical engineering have the same instruments and electronic devices. No business organization could long survive operating under such conditions—millions of dollars' worth of duplicate plant, inoperative most of the time!

The consolidation of laboratories would avoid duplication, while the use of one laboratory by several different curricula would permit scheduling for a better load factor. And, finally, the machine shops and mechanics staff needed to service the consolidated laboratory would be less costly than that for separate and independent laboratories.

The great flexibility inherent in the proposed organization for setting up new curricula, or combinations of old curricula, without necessitating entirely new departments, should not be overlooked. For example, a combined M.E.–E.E., five- or six-year curriculum in *power* could be established without even adding new courses. Or a combined E.M.–Met.E. curriculum could be formed. The opportunities for educational experimentation, without costly committments, are unlimited. Any experimental setup which proved to be a dud could be dropped quickly and without embarrassment. All combinations and variations are made possible and feasible when the instructional service departments are considered fixed establishments, and the curricula, simply as variants of fundamental engineering training. Unorthodox programs can easily be established in special cases.

Possible Disadvantages

Two possible disadvantages to the proposed plan have been suggested:

1. Students would not feel that they belonged to a curriculum or professional group to the same extent as they do under the conventional system.

2. The service departments might tend to support the needs of one or more curricula at the expense of the others.

It is hard to see how the first objection would be of more than passing concern. Every student would be enrolled in the curriculum of his choice, under the guidance of a curriculum director. The same courses would be given that are now offered in each curriculum. Graduates would receive the same degrees offered under the conventional system. Students would work with as many specialists in their chosen professional field as before. It should not concern the student at all that his instructors and laboratory equipment belong to the college of engineering as a whole, rather than to a specific curriculum. Any imagined lack of stimulation in a particular branch of engineering would be compensated for by a greater appreciation and understanding of the unity of engineering as a field of knowledge and endeavor.

The second objection could become very real if a particular curriculum director proved inadequate to his task, or if the dean of engineering failed to exercise proper supervision and surveillance. But does not the same situation develop under the present system and for exactly the same reasons? In fact, uniformity of performance under the proposed plan would be far easier to obtain than with our present system of semi-independent and autonomous departments where so much depends on the characteristics and personality of the department head.

Conclusion

To set up the proposed plan in an established college would, of course, be a difficult operation, without the wholehearted support of the entire engineering faculty and administration. A number of "empires" would have to be liquidated, and it might prove embarrassing to find equivalent berths for the old department heads. For example, if the head of the M.E. department was a machine designer, and the head of the C.E. department a structural designer, both might want to head the new Design department, leaving the Power and General Engineering & Construction departments with no available heads. Moreover, the physical transfer and moving of laboratory equipment to new locations for the purpose of consolidating might prove costly and thus not be feasible.

The transition might well require many years and major changes. The ideal situation would be a fresh start with new equipment and a staff specifically recruited for the purpose. Since this is not a likely possibility, the best alternative is to undertake the necessary changes in succession, as rapidly as suitable staff, laboratory facilities, and space become available.

ASEE 66TH ANNUAL MEETING

Berkeley, California, June 16 to 20, 1958

FACULTY COMPENSATION POLICIES AND PRACTICES

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Presented at the ECRC Conference for Presidents, Institutional Representatives, Deans, and Directors of Research, 65th Annual Meeting, Cornell University, June, 1957.

Questions of salary and salary policy are difficult to view objectively since often they are directly related to one's own experiences, convictions and prejudices. However, Dr. H. E. Longenecker (1) has reported an excellent survey of University policies and practices, based on a comprehensive review of the literature and on personal visits to twenty-four representative universities. Also, Professor V. E. Neilly (2) has made a comprehensive study of the policies of Engineering College research organizations, and the Engineers Joint Council (3) has recently surveyed engineering salaries.

These studies have provided valuable background material for this paper and are recommended to anyone who must formulate or administer compensation policies and procedures. While the findings may not be entirely applicable to particular situations, information concerning modes of operation and institutional problems can be helpful—if only as an indication of the kinds of problems that arise.

This paper introduces the additional factors of salary administration for research workers in engineering colleges. It was prepared with the conviction that if research programs are to prosper in an academic environment, a realistic comparison between teaching and research staffs must be made for salaries, promotion opportunities, and responsibilities.

Objectives of a Sound Salary Policy

It is surprising how many administrators struggle with unworkable policies merely because they have become "accepted." A good salary policy should, like a comfortable environment, result in a complete lack of frustration, and produce a feeling of exhilaration. The staff should have a minimum concern about salary, and, *most important*, a complete lack of awareness of salary policy as such. In other words, the staff should feel well provided for, and untroubled as to whether policies will restrain individuals, discriminate against them, or permit injustices such as unwarranted promotions.

It has been said that a college teacher is willing to work for a *modest* salary as long as his colleagues also get a *modest* salary. The principle still holds. However, in these days of staff shortages, keen competition, growing student enrollment, and active research programs, "colleagues" exist on a national basis rather than within a single department or college. Also, the word "modest" has taken on a new meaning in recent years. Yet comparisons among staff members are a psychological factor that cannot safely be ignored.

The primary responsibility of an administrator is to evaluate and counsel his staff in a way that makes it more productive. If, at any time, a staff member feels that his efforts are

not being recognized—by salary level, by promotion, or by assigned responsibilities—a productive man has been lost, either completely or at least in cooperative spirit.

Salaries and promotions affect the very core of the relationship between the staff and the responsible administrative officer. These are the *tangible* evidences of recognition for outstanding performance. Such devices as automatic raises, across-the-board raises, time-table promotions, and rigid maximum and minimum salary scales, are often recommended by faculty committees, and all too often, gratefully accepted by administrators as the easy way out. However, they are sure methods of driving off the most competent staff members and developing an "automatic faculty" who are content to walk a threadmill and plod through a "cradle-to-grave" planned career.

To be effective, a salary policy must *permit* and *require* administrative judgment, evaluation, and ability to act. Admittedly, available funds and general regulations often curtail administrative action. The administrator's problems are complicated further by staff members who have overly exaggerated opinions of their own abilities. Nevertheless, outstanding performance must be recognized, and rewarded, in the development of a high-caliber staff.

Conditions Related to Base Salary

Every institution has what is termed a "full-time appointment." Personal observation and particularly, Professor Neilly's report, point out the fact that there are many variations in the terms of such appointments. The annual work period can be cited as an example. Professor Neilly found the following distribution of the normal work year for the teaching staffs of 97 engineering colleges:

9 months	66
10 months	11
11 or 12 months	9
Combinations	11

In the case of research workers, 94 engineering colleges have the following distribution of months in the work year:

9 months	5
10 months	1
11 or 12 months	82
Combinations	6

Vacation allowances, annual leave, and other factors affecting the work year also varied considerably. To these can be added the variables in retirement benefits, health and hospital plans, and other features of the so-called "fringe package." Many of these variations in the *terms of employment* materially affect the base pay rate and should be taken into account, both by the individuals affected, and in published salary surveys.

Several other important factors are related to the base salary of a University staff. Both public and private schools have detailed procedures and barriers to rapid adjustment of salary funds. One must either wait for legislative action, raise more endowment funds, raise income from tuition, or wait for a windfall. Meanwhile, the cost of living climbs, the value of the dollar declines, and any fixed income covers less of the cost of operation. This *time lag* between recognition of need and receipt of funds presents a serious problem for universities—particularly in the planning and budgeting of salary funds.

It is also difficult to change the *distribution* of funds between colleges within the university structure—even when the pressure of competition is felt most by certain colleges. The evidence is strong that engineering colleges require more funds to keep

up with the rapidly increasing salaries that are resulting from the current demand for engineers. The hiring of new staff members necessarily creates inequities if the base salary level of the existing staff cannot be adjusted. One consolation is that these inequities eventually raise the level of staff salaries, but this type of boot-strap operation, often creates much dissatisfaction and concern.

A factor related to base salary that can be illustrated by any plot of salary versus years of experience, is the need for a salary "growth" pattern. Observations made several years ago in comparing a group of industrial salaries with those of the Engineering College Staff at the University of Illinois indicated the need for a growth rate of from 3 to 5 per cent per year just to keep salaries on the curve. The recent EJC salary survey also brings out this point.

Under conditions of equilibrium one might expect the surplus salary resulting from replacing senior staff, as they retire, with young instructors, to provide funds for salary growth. However, when the staff is predominately young, as is the case in most institutions today, the "savings" from salaries of retiring staff are not at all adequate for this purpose. A "status quo" budget does not provide for normal advances related to length of service, but, instead, represents a *reduced* budget in this regard. About a 4 per cent increase per year is required to keep staff salaries on a normal "growth" curve, independent of increases due to exceptional merit, cost of living, or competitive salary increases.

Salaries for research personnel must be adjusted on a similar basis, regardless of whether the research staff is made up of the teaching staff (on a part-time basis), or employed solely for research. The growth factor creates serious budgeting problems on research contracts established for long periods in advance, such as those supported by "longevity funds."

Conditions Related to Extra Compensation

Dr. Longenecker's report contains considerable information on practices relating to extra compensation. Also, he has included a great deal of material dealing with historical events and present-day thinking about such things as consulting work, terms of employment, and staff responsibilities to institutions.

Many national educational organizations and individual schools have also deliberated at length concerning the appropriateness of extra compensation for staff members. The attempts of several universities to provide and enforce a realistic full-time annual appointment are well known to all. However, even though such attempts have been continuous since before 1900, extra compensation through outside activity is very prevalent today.

Professor Neilly found that 95 of 98 institutions queried permit academic staff members to do consulting work for compensation in addition to their institutional salaries. Only three prohibited consulting during the academic year. Seventy-four restricted the amount of consulting work allowed, while 22 made no restriction whatever. The restrictions mentioned were expressed in terms of dollars, per cent of salary, time, or a combination of these and similar measures.

Thus we can conclude that engineering colleges, at least, are far from giving up "outside" activities for extra compensation. Also, there are few restrictions as to who may do consulting; 81 out of 96 engineering colleges have no such restrictions.

The Neilly report does not mention

separate policies for research staff, as compared to teaching staff, in the matter of outside consulting. However, personal observations would indicate that at some schools, a wide variation exists. This may be because a "full-time" researcher might be considered to have different responsibilities and obligations than his teaching counterpart. On the other hand, there is the well known argument of the teacher who claims that the researcher gets all the credit and promotions while he (the teacher) does all the worth-while work. One way to resolve this conflict is to follow the principle that the teacher and researcher should be one and the same person and that the teaching and research program should be integrated into an effective educational package.

As to the question of extra compensation for sponsored research conducted *within* the institution, the Neilly report indicated that 63 institutions paid extra compensation while 23 did not. Eight more permitted extra compensation only under special circumstances. The restrictions as to amount of earnings and time allowed varied considerably, from "summer work only" to "67 per cent of the institutional salary."

Many values have been assigned to extra activities for staff members—not the least being extra income to augment institutional salaries. Other values are not without merit when we consider the unique position of the faculty member in relation to the student and to society. A partial list might read as follows:

1. Permits the faculty member to keep up with his field.
2. Provides fresh and practical problems for classroom presentation.
3. Provides public service and counsel by an unbiased individual who is outstanding in his field.
4. Provides close liaison with industry.
5. Is a method for industry to support higher education.
6. Serves an educational function to those outside the University.
7. Brings new problems to the University for study.
8. Assists the University through new research sponsorship.

Needless to say, *all* of these advantages do not *always* result from the consulting activities of the faculty. Conversely, there are definite problems which do occur with sufficient regularity to suggest certain controls on the type and amount of consulting to be done by the staff. The most serious of these might be broadly termed "conflict of interest" between the dual employers—the University and the outside organization.

Conflict of Interest

Many organizations require consultants and short-term employees (summer staff) to sign the same type of patent regulation as is required of regular employees. One type in particular which has dangerous potential is an agreement that all patentable ideas developed by the individual for one year after leaving the company will be the property of the company. It is obvious that many problems could arise from this same man developing a patentable idea within the scope of his University work.

The situation may well be complicated further by a third party—an industrial or government sponsor of a contract with the University in which the man is employed. Numerous examples have occurred where a program best suited as sponsored research with the University organization has been conducted on a private basis by a staff member for extra compensation. Not infrequently, the

staff member uses University equipment without proper payment, and hires student labor without proper provisions for accident insurance, workman's compensation, and other conditions.

Another embarrassing case is that of the staff member who is called on by his outside employer to give expert testimony at a trial for a fee. This can result in hardship or embarrassment to the University, or to a competitor who has close relations with the University through sponsored research or other activity. The mere fact that the staff member is employed by the company makes his "expert" status questionable.

The use of the University's name in connection with outside activities has also caused considerable difficulty. Outside employers take great pride in the University connection of their consulting staff, and misuse this association in many ways. Advertising is the most damaging of these—because of the broad public it reaches. However, other more subtle methods (such as reference to the staff member in personal talks or letters to clients) are more difficult to control.

Thus it is essential that staff members take every precaution to serve outside employers as individuals, and not as members of the University staff. Such precautions as using private stationery and a postal box, requiring that the University's name not be used, and stating that the University is not responsible for actions and continuation of the work are the least a staff member can do when accepting additional employment outside the University. The University, on its part, should assist in every way to keep the relationship clean-cut by charging for use of equipment, insisting on its name not being used in advertising or otherwise, and providing regulations that can be followed without the necessity for "back-door" operations. It should also insist that the administration, particularly the department head and/or the dean, be informed of outside activities, not to be restrictive or dogmatic, but to provide counsel and assistance in the interpretation of the written and unwritten rules.

In view of the numerous difficulties that have resulted from dual employment, there is little wonder that a number of universities have, at various times, attempted to eliminate outside activities, and to formulate a salary structure based on "full-time annual employment." Attempts have even been made to require that faculties turn in all income from outside activities—with the obvious result that those who could and did earn extra compensation were unhappy because others could not or would not do so. It would appear that, in modern society, the faculties of our universities are not sufficiently communal in nature to support such a plan.

Where research conducted within engineering colleges is involved, there is the additional problem of extra compensation for work done "within" the University. Should this work be done only on released time of the teaching staff, with or without the assistance of a separate research staff? Should extra compensation be paid for research, and the work scheduled on an overtime basis? If so, should this directly affect the amount of "outside" consulting a particular staff member might do?

Should consulting work, testing, and research all be channeled through the University, even though the staff member receives extra compensation for this work? What is the relationship between research which is expected of a faculty member as part of

his academic accomplishments and the sponsored research program that may or may not provide extra compensation?

These and many other questions arise which may have quite different answers, depending upon the operation and objectives of the research programs in the various colleges of engineering. While it would be virtually impossible to formulate a uniform policy for all colleges of engineering, much can be gained through discussion of faculty compensation policies and the interchange of ideas on methods of solving the kinds of problems indicated herein.

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(3) Report Number 102, "Professional Income of Engineers, 1956." Prepared by The Special Surveys Committee of Engineers Joint Council.

COLLEGE NOTES . . .

Dr. Carl S. Ell, currently in his 48th year with Northeastern University and his 18th year as its President, will retire on June 30, 1959. It is expected that his successor will be named within the year. His retirement will mark the 42nd year of his membership in ASEE. Dr. Ell was a member of the Council from 1940 to 1943. Dr. William C. White, former Vice President of Northeastern, became the first Provost of the University in January. A very active member of ASEE, Dr. White is currently Vice Chairman of CDEF.

Dr. Thorndike Saville, Dean emeritus of New York University College of Engineering, has been named to head a study on the development of the University of Florida's Science and Technology Center. The study will be financed by a grant of $75,000 from the Ford Foundation. The University of Florida, located in Gainesville, is unique among universities in the entire coastal region from Maine to Texas in that it has, on a single campus, the colleges of agriculture, engineering, liberal arts, and medicine. Dr. Saville's project is concerned with the establishment of an integrated center of science and technology in which all of the colleges will participate through teaching and research.

John R. Bowman has been appointed Associate Dean of the Technological Institute and professor of science engineering at Northwestern University. A chemical engineer with the doctoral degree in mathematics and biology, Dr. Bowman was formerly director of research at the Mellon Institute, Pittsburgh.

INTELLECTUAL AND NON-INTELLECTUAL FACTORS INVOLVED IN PREDICTING ENGINEERING SUCCESS

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Engineering education in the next decade will cope with many problems. The increasing demands of contemporary society for more scientific, engineering and technological personnel, an ever increasing college population, and the quest for depth and breadth in the engineering program are typical concerns of engineering teachers and administrators. Considerable faculty time is spent discussing these problems, whether in the time-honored bull-session or the omnipresent committee meeting. These discussions often include student mortality and invariably student prediction is suggested as a partial solution.

In this paper I would like to review some of the previous studies and then discuss some of the limitations involved in predicting student success. The factors involved in predicting student success might be classified into two broad areas namely, intellectual factors and non-intellectual factors. Intellectual factors would include those things normally associated with scholastic aptitude: intelligence vocabulary, mathematical ability, etc. Non-intellectual factors would include those factors independent of ability or aptitude, but often associated with scholastic success: motivation, interest, study habits.

Intellectual Factors

Aptitude testing of engineering students goes back almost as far as the group testing movement itself. In 1919 the Society for the Promotion of Engineering Education, through a grant furnished by the Carnegie Foundation for the Advancement of Teaching, conducted the first of many large-scale investigations of engineering education. The late E. L. Thorndike was consulted and asked to examine the relationship between high school grades, orientation tests, and first-term freshmen grades (1). In a report based on Thorndike's study of 48 engineering schools, Mann (2) reported an "average correlation" of .46 between first semester grades and the "average of six orientation subtests (arithmetic, algebra, geometry, intelligence, physics, and technical information, later known as the Thurstone Vocational Guidance Tests) and an "average correlation" between first semester grades and high school grades of 0.29.

Another investigation of national proportions was conducted by Hammond and Stoddard, as part of the famous "Report of the Investigation of Engineering Education, 1923–29," more commonly known as the "Wickenden Report" (3). This study in-

cluded 27 representative engineering colleges; correlations of about 0.50 were reported and correlations of "composite" scores with first semester grades ranged from 0.65 to 0.75.

Further information on the development of the testing movement in engineering before 1940 can be found in Kandel's study (4), in which he concluded that mathematical ability is the best single engineering predictor and is probably better than a considerable battery.

In the early 1940's, there was a growing demand for a special test specifically designed for the selection of engineering students. The development of special engineering aptitude tests at Lehigh University in 1926 is cited by Formhals and Stoughten (5) in an article which made a strong plea for the "highest possible selectivity" since 56.5% of those who enter do not graduate and only 28 out of 100 of them graduate in the class with which they entered.

About this time, considerable interest was expressed in requiring at least two years of college work before entering the professional engineering schools. Sackett (6) in a report to the Engineering Council for Professional Development Committee on Selection and Guidance strongly condemned the policy of "selection at the end of one or two college years" as "hope deferred, and often it is faith destroyed in the young, ambitious, hard-working, but ill-prepared student who finds himself floundering in a troubled sea." He went on to recommend "better counseling as a first step in intelligent selection." These demands, coupled with the rapid development of the testing movement in the U. S., resulted in at least two prominent tests of engineering ability –the Engineering and Physical Science Test and the Pre-Engineering Inventory.

The Engineering and Physical Science Test (EPST), developed at Pennsylvania State College, from a composite of standardized tests, was developed primarily for the Engineering and Science Defense Training Program. In one of the earliest reports on the development of the EPST, Griffin, and Borow (7) reported multiple correlation coefficients of 0.79 and 0.71 between mathematics, physics, and chemistry grades and weighted parts of the test. Other validity studies on the EPST for engineering populations are reported by Treumann and Sullivan (8) at the University of Wisconsin and by Gregg (9) at Colorado University. Gregg reported a validity coefficient for the total test of 0.63 using electrical engineering grades as a criterion.

Perhaps more engineering studies have used the Pre-Engineering Inventory than any other test. The origins of the Pre-Engineering Inventory are discussed at some length by Vaughn (10), Sackett (11), and Eshbach (12). The Pre-Engineering Inventory was based originally on Crawford's Yale Scholastic Aptitude Tests (13). After extensive development by Bartlett (14) and Vaughn (15), the Pre-Engineering Inventory was subjected to many local (16, 17, 18) and national validity studies (19).

Although validities from 0.39 to 0.63 were reported, the six-hour length of the Pre-Engineering Inventory limited its usefulness (20, 21); a shorter form, later known as the Pre-Engineering Ability Test, was developed (22, 23, 24, 25). Recent studies of the Pre-Engineering Ability Test have resulted in conflicting opinions as to its usefulness. Drake and Thomas (26) report that the "Pre-Engineering Ability Test, with either ACE or centile rank in high school graduating class, separated the high achieving students from the poor achieving students very

well." Sessions (27), concludes that the "Pre-Engineering Ability Test has little selective value compared with other tests in common use."

Mechanical Comprehensive Tests and engineering grades were compared by Owens (28) who reported correlations of about 0.40. Halliday, Fletcher, and Cohen (29) reported the following validities for the Owens-Bennett Mechanical Comprehension Test: 0.42 (first quarter grade average), 0.43 (Engineering Drawing).

The Differential Aptitude Test Battery was used by Berdie (30) to study the prediction of grades for engineering students at the University of Minnesota, in which he concluded that "the tests were not of sufficient difficulty for use with engineering students and resulted in validities similar to other academic aptitude tests."

Another approach to predicting engineering success is the multiple test battery approach, in which a whole battery of predictors are administered to engineering students and correlated with the criterion. In general, multiple predictor studies report correlations from 0.60 to 0.81.

At Purdue, Johnson's study (31, 32) of 244 of the entering Freshman Engineering class in 1939 provided perhaps the most extensive testing on any single population: nineteen psychological and physical tests yielded 57 test scores. High school decile, hours of study, and 15 personal data items were also obtained. A correlation of 0.700 was reported between first semester grades and the Iowa Mathematics Training Test. A "shrunken multiple correlation" of 0.788 based on the Iowa Mathematics Training Test, Cooperative Intermediate Algebra, tenth of high school graduating class, and Thurstone's "V" Factor test was also reported using first semester grades as a criterion.

Remmers, Elliott, and Gage (33, 34), in a study of curricular differences in predicting scholastic achievement from orientation scores, developed the following prediction equation for engineering students (first semester freshmen):

$$Y = .491X_1 + .419X_2 + .149X_3 - .253X_4$$

where

X_1 was the Purdue Physical Science Test,

X_2 was the Purdue Placement Test in English

X_3 was the Purdue Mathematics-Algebra and Arithmetic Test

X_4 was the ACE-L score

A multiple R of 0.671 was reported using first semester engineering grades as a criterion.

Another one of the more complete studies of the relations and inter-relations at Purdue University between orientation tests and first semester grades was conducted by Baker (35) who studied the inter-correlations among 33 variables for the 1948 class. He reported a multiple correlation of 0.77 between first engineering semester index and six of the "most efficient" predictors (Purdue Physical Science-Mathematics Operations, Purdue English-Reading, ACE-Arithmetic, Purdue Physical Science-Scientific Facts, Purdue English-Grammatical Errors, and the Purdue Physical Science-Problem Analysis). In his cross-validation study of the incoming 1953 class, Baker reports a correlation of 0.60 between predicted grade index and obtained index.

Baker, Winer, and LeBold (36) factor-analyzed a 28-variable inter-correlation matrix based on Baker's original study. Four factors (general-verbal, mathematical achievement, abstract-reasoning and scientific-reading scholarship) had substantial loadings on the first and second semester fresh-

men engineering scholarship variables. Two other factors, a physical science background and a language-mechanics factor, were only negligibly related to engineering grades.

In summary, we might say that correlation coefficients of 0.6 for individual tests and 0.7 for multiple test batteries seem to be upper limits in predicting engineering success from cognitive measures. But let us not be too content with these values, because the values should really be squared to obtain a better picture of how much the predictors and the criterion have in common.

$0.6^2 = 0.36$—for single tests
$0.7^2 = 0.49$—for multiple tests

This means that between one-third and one-half of the variability is accounted for by the predictors— and these are *upper limits* of accuracy. Schools that are selective or those using less relevant predictors would not be able to predict nearly so well.

Non-Intellectual Factors

One does not have to be around an engineering school very long before he recognizes that there are many non-intellectual factors that influence student success. Some of these factors are of considerable importance to some students and unimportant to others. We have been examining some of these factors at Purdue and have found some interesting results:

1. Often when we speak of the attrition rate in engineering schools, we make the erroneous assumption that most of these students drop out because of poor grades. Yuthus (37) studied students enrolled in engineering at Purdue in 1950 who withdrew from engineering during their freshmen or sophomore year. The reasons were multiple. The more important reasons were as follows: lack of interest, poor grades, entering military service, and finances.

2. Frequently, poor study habits and conditions are cited as reasons for poor grades. We attempted to measure this last year by asking students for self-reports. We did not find it possible to measure any relationship, but there are many factors that confound such studies.

3. We have been interested in determining whether or not there is any relationship between housing and grades. We found that the engineering students living in the married student housing had the lowest high school rank and orientation scores, but above-average first semester grades. In contrast to this we found that the fraternity students had very high orientation scores and high school rank, but below-average first semester engineering grades (38).

These are but a few illustrations that serve to explain why our predictions are far from perfect. Many other factors might be cited, such as the motivational level of the student, non-academic activities, family problems, and other similar influences.

What are the implications for the engineering teacher who counsels the individual student?

1. Tests are valuable guides for the individual student however, engineering counselors should be careful not to stress unduly their importance.

2. Many nonintellectual factors are also important in predicting student success. Effective counseling should attempt to determine the non-intellectual factors that apply to the individual student.

3. In view of the contemporary limitations involved in predicting engineering success, we must be very careful of speaking with any finality regarding the potential success or failure of any individual student.

In summary, we might say that we can predict engineering success with better than chance accuracy. However, there is still an unknown area of considerable importance that demands additional research, which should continue to challenge engineering education in its search for understanding.

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THE GROWTH AND DEVELOPMENT OF THE ENGINEER IN INDUSTRY

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There is an urgent need for procedures which will ensure optimum professional growth of engineers, especially those just starting their careers in business and industry. This problem is fully as critical as the nation's technical manpower shortage, because it involves making the fullest and best use of available personnel.

That industry has a place for the product of our engineering colleges is evidenced by the heavy demand for graduates. However, the failure of many engineers to grow professionally is disappointing. It results in the assignment of engineers to routine or semiprofessional jobs, to the detriment of industry as well as themselves.

The prime responsibility for professional growth rests with the individual. But as in any human improvement process, he needs teaching, guidance, encouragement and related stimuli to achieve his goals. Thus, establishing a sound foundation for professional growth and development requires the combined efforts of educators, industry, and the engineer himself. All three must be fully aware of the factors involved and the part that each must play. Otherwise, industry's younger technical people will fail to achieve proper professional growth and development.

Role of the Educator

All too often the young engineer expects that the effort he has expended in obtaining a degree will carry him through life. He has ambitions for advancement but no concept of what he must do to prepare himself to progressively take on new responsibilities.

He tends to look upon his engineering degree as an end in itself, without realizing that education is a continuing process. He mourns his lack of professional status, but does not realize that he lacks the judgment of the true professional.

Perhaps too much is expected of him. Possibly, these attitudes are characteristic of the young and inexperienced. However, industry finds that many of these men graduate without the slightest idea of how, or in what direction, they are expected to develop.

Incentives can and should be instilled during the engineer's college years. It is the educator who can make the undergraduate aware of the factors that will affect his future development in industry. Some engineering colleges have already made substantial progress in providing industrial orientation for their students. Perhaps this discussion will add encouragement and conviction to their methodology.

The idea that an academic degree is the end of the road is a vicious one. A degree, alone, cannot evidence professional arrival. Professional status is *earned* through professional *practice*. Educators are urged to stimulate the engineering student to a more active interest in continued professional growth—growth that does not stop with the acquisition of a degree.

The undergraduate is used to working at least 50 to 60 hours a week. If he isn't careful, he'll be trapped by the 40-hour week—by what the E.C.P.D. terms "the post-graduation slump." He just isn't going to develop on a program of 40 hours per week.

Not only must the engineer keep up-to-date technically, but also he should learn more about communication skills, economics and other non-technical subjects. He can acquire some of this knowledge in night school and company training programs. However, the importance of a wide range of reading cannot be overemphasized. Educators should make this clear, encouraging their students to develop breadth as well as depth of knowledge.

The engineer must expand his interests if he is to continue to grow. In the limited time available at the university, it may be difficult to teach him much about communication skills or human relations, but a good start could be made and he could be counseled to continue after graduation.

Communication Skills and Human Relations

Industry spends fabulous sums of money and time to remedy deficient reading, writing and speaking skills. These deficiencies result from a secondary school system which encourages just about everything except hard work and a required core of fundamentals. But universities perpetuate this condition by easy entrance requirements and technical course grades which seldom reflect the lack of these skills.

Christian K. Arnold [1] says, ". . . engineering students, for the most part, do not feel the need to learn basic communication skills; and neither do their teachers. . . . In other words, the instructor must *act*, not just give lip service to the premise that basic communication skills are expected of all people engaged in collegiate-level work." He then goes on to outline an effective program for engineering educators. These are encouraging words, coming from a university administrator. They would be even more encouraging if they came from a Dean of Engineering.

Engineers are usually taught writing and speech separately, quite often by an inexperienced instructor from the Arts College who feels that he has been exiled to Siberia. This segregation isolates the engineer from other attitudes and points of view. At the same time, segregation presents a dilemma for the instructor. He can't very well fail the entire class for lack of interest and poor work. Yet the same performance would call for failure if the men were competing with liberal arts students.

If we recognize the principle that *all* university graduates must be proficient in communication skills, the answer to such segregation seems obvious. Students of law and medicine learn to write and speak in the Arts College; why should it be different for engineers?

The young graduate may start out with small projects, but bigger assignments soon come his way as he gains experience. On the larger projects, industry is learning the economy of providing technicians, draftsmen and data clerks to assist him. Thus, today's engineer finds that he must soon learn about people: how to work with them and through them; how to influence people by making his ideas clear and interesting; how to participate in conferences. F. J. Roethlisberger takes a dim view of the engineer's

[1] "What the Technical Teacher Can Do to Improve Training in Writing Skills," *J. of Eng. Ed.*, Vol. 48, No. 2, pp. 90–95 (Nov., 1957).

competence to deal with human relations:

"Were it not that . . . engineers have to cooperate with other groups and that sometimes engineers move into administrative positions, this difficulty in understanding the nature of cooperative phenomena would make no difference. However, when an engineer becomes an administrator he becomes, whether he likes it or not, concerned with a class of phenomena to which his former specialty has no relevance. Some engineers recognize this and accommodate themselves accordingly; others do not—they continue to handle cooperative phenomena as if they were handling a machine, more often than not with disastrous results."[2]

According to estimates, only about 10 per cent of job failures are caused by technical incompetence. The others result from a lack of initiative, the failure to finish what is started, and the inability to understand people and work with them. Today's emphasis on the team approach is making it more difficult for the lone wolf to succeed in his profession.

Industry finds that cooperative (work-study) engineering programs produce students who are more aware of these problems and have made greater progress in developing human relations skills. However, such cooperative programs are not practical for all engineering colleges. What else can teachers do?

First, they can emphasize the importance of acquiring these skills. Secondly, they can guide the engineer's choice of electives to include training in human relations. Courses that actively develop an understanding of human behavior, coupled with laboratory practice, are preferred to those that only preach principles. Examples are the Harvard case method of teaching human relations and the group dynamics approach of the University of Michigan. Finally, educators can encourage their students to participate in a wide range of extracurricular activities, preferably those which include all kinds of students.

Communications skills and human relations skills are so interwoven that one can hardly be developed without the other. The combination is just as vital to the engineer's success as are mathematics and the engineering sciences.

Industry's Obligations

One of industry's first responsibilities is to continue the guidance and counseling begun by educators, so that the route toward professional development is clearly defined for the new graduate. Equally important, industry must provide the time, opportunity, and support for professional growth.

The young engineer's development will be frustrated if only top management and training directors subscribe to this philosophy. Every first-line supervisor must recognize his obligations and provide adequate time and thought to discharging them. This is not an easy assignment for the supervisor. However, industry is training its supervisors in this area, and is constantly improving its training methods.

Many companies have developed orientation and training programs to ease the transition from academic to industrial life and to assess the engineer with a view toward sound job placement. The young engineer should not look upon these programs as an unwelcome delay in taking up his permanent duties, but rather as a valuable opportunity to develop healthy attitudes toward his job, his associates, his employer, and his profession.

[2] *Management and Morale*, by F. J. Roethlisberger, Harvard Business School, Graduate School of Business Administration, Harvard University Press, Cambridge, Mass., 1955.

An employer conscientiously interested in seeing a newcomer achieve his full potential must let the engineer know what is expected of him. But the employer must also provide him with the opportunity to perform a series of challenging jobs and must let him know how well he is fulfilling expectations.

Many engineers are retarded in their development by careless placement on their initial jobs. The job must match the engineer's qualifications and interests. If the man is overqualified for the job, he stagnates and soon loses interest. If he is markedly underqualified, he is afraid to accept responsibility and never gains confidence. The ideal job assignment extends the engineer a *little* beyond his capabilities of the moment. It gives him the opoprtunity to perform without having his supervisor meddle in the details.

Myles Mace [8] has said that the most effective way of developing people is through coaching by their supervisors. The engineer must have confidence in his supervisor as a teacher, and the supervisor must demonstrate confidence in the engineer's ability to fulfill his expectations. This means that the engineer should make every effort to know his supervisor and to be known by him. Supervisors should recognize these efforts, encourage them and respond to them, building a bond of understanding and confidence.

The engineer must try to understand his supervisor's needs and his style of leadership. The supervisor can help here, too, by making clear his needs and methods of operation. The delegation of authority and responsibility to the engineer does not excuse him from keeping his supervisor informed, however. His supervisor is entitled to progress reports, and he should know about unexpected difficulties, especially those that affect budgets, safety or timetables. This the supervisor should also make clear to the new engineer.

And what about the engineer's mistakes? He should never hesitate to report them promptly. And his supervisor shouldn't expect him to know everything. His mistakes should be regarded as part of a process for sharpening judgment.

The engineer's personal program of professional development is best planned in consultation with his supervisor. He should tell his supervisor about his ambitions, the changes he would like to see made in the job, his long-range plans, and the additional training and experience he would like to have. In return, his supervisor should let him know what he is doing well and what he is doing poorly.

Supervisors should recognize the profound effect they will have upon the new engineer's professional career. Quality of leadership is an important consideration, both in the selection of a job and, later, in the evaluation of that job. If the engineer's organizational group lacks good leadership, he will have to take positive steps to improve his situation.

The Management Outlook

Engineers need to develop the management outlook. American Cyanamid's S. C. Moody has said it well:

"The professional employee is a worker; but, to a large extent, he determines his own methods of working and sets his own standards. He needs the managerial outlook; yet his primary function is not to manage."

If this is true, then it is high time that industry develops some consistency in

[8] *The Growth and Development of Executives*, by Myles L. Mace, Harvard Business School, Division of Research, Soldiers Field, Boston 63, Mass., 1950.

its treatment of engineers. A management outlook is not cultivated by treating the engineer like common labor. Companies that give their engineers subprofessional work, require them to punch time clocks, deny them reasonable office privacy—these are the companies that complain about unionization of engineers and lack of professionalism. How naïve can they be?

Employers should become familiar with *Criteria for Professional Employment of Engineers.*[4] The basic principles which guided the development of these criteria are:

1. The only satisfactory method of dealing with engineer-employer relations is on a cooperative common-interest basis.
2. The engineer shares an equal responsibility with the employer in elevating his professional status.
3. Management should regard the engineer as one who is identified with the "management team," whether the engineer is in a supervisory or non-supervisory position.
4. The enginer must be "company minded" and think in terms of the company's problems and growth, as well as his own.

Responsibilities of the Engineer

The engineer must know the "why" of the approach which is being followed by educators and industry. Of greater importance, however, is his realization of the factors involved and the part which he must play in the successful execution of the development program. He must recognize that although others are attempting to help him, professional growth means *self*-development. This is his most important responsibility.

Frequent reference has been made to the need for continued study in technical, business and cultural fields. Many companies today have established educational assistance programs, whereby the employer pays a large part of the expense involved in additional course-work. Supervisors and training personnel can assist the engineer in developing his program.

Many "reading lists for engineers" have been published, but the engineer should be cautioned against blindly accepting such recommendations. There is no one "right" list for all engineers. Besides, each man should have the fun of developing his own range of reading interests.

For those who are slow readers, a course in reading improvement would be worthwhile. The incentive? Well, some psychologists claim that the well-read man is usually a successful man. Some experts claim that vocabulary tests provide as good a prediction of ultimate success in life as do intelligence or personality tests.

The young engineer should become aware of his civic and social responsibilities. There are many opportunities for the engineer to make his training and experience available to the community. He can attend meetings where controversial projects are being discussed, accept political offices, serve on study or advisory committees, and accept appointments to commissions. He can make direct use of his technical background in such areas as civil defense, sewage and sanitation, air and stream pollution, transportation, airports, municipal parks, school construction and many others.

These opportunities may come about through local government, the professional societies, or the engineer's employer. The opportunities will be small at first, but greater responsibilities will come as the engineer demonstrates interest, ability and willingness to serve. Contacts with people and problems outside of his regular work are certain to broaden

[4] Copyright 1956: National Society of Professional Engineers.

the engineer's perspective, stimulate his interests and increase his over-all effectiveness.

In the educational field, there is a need for citizen study groups to inquire into school facilities, staffs and curricula. The enginer can also be of public service by teaching technical subjects at night in local high schools and universities.

The first step in professional identification is membership in a professional society. This identifies the engineer as a professional who meets its qualifications for membership. Such membership is both a privilege and an obligation.

Few of us have ample opportunity to meet and talk to other enginers, particularly the leaders of the profession, except through these societies. The professional societies provide guidance and speak for engineers with the strength of numbers. They maintain the standards of the profession, promote recognition and advancement and give us the valuable publications needed in our work.

Consideration of these services suggests another reason for joining a professional society and becoming active in it. Engineers have a responsibility to repay the profession for the services which they have drawn upon so heavily in arriving at their present level of education and experience. They can do this by their financial contributions, by serving on committees, by contributing technical papers and by holding office. Without such support the work could not go on.

The engineer should begin, of course, at the local section level. He will soon find that the more he puts into a professional society, the more rewarding the experience and the more support he will receive from his company. The engineer cannot expect his company to pay his expenses to a national meeting if he isn't a member of the society or, being a member, doesn't even attend the local section meetings. As he develops a broader interest in technical and educational affairs, he may eventually wish to join organizations, such as the A.A.A.S. and the A.S.E.E.

The second big step in professional identification is to become registered as a professional engineer. Since the enactment of the first engineering registration law in Wyoming nearly 50 years ago, all of the states and territories have followed suit. Today, registration not only protects the public but also adds dignity and stature to the profession.

Sometimes an engineer employed in industry finds it hard to understand why he should be registered, when the law appears to exempt him from its requirements. This lack of understanding arises partly from the failure of most states strongly to enforce engineering registration laws.

There does not seem to be any question that industries having fire and explosion hazards, waste-disposal problems or toxicity hazards come under the statutory reference to "safeguarding of life, health or property." A trend toward stronger enforcement has already begun and will eventually require that those in "responsible charge" be registered. Engineers who are not registered may someday find themselves barred from other jobs or promotions.

Even though the primary purpose of a registration law is to safeguard the public against incompetent and irresponsible persons, it has an important corollary. Registration certifies that the engineer has been examined impartially by respected members of his profession and that he possesses the required technical qualifications and an understanding of his professional responsibilities. Such recognition is a source of personal satisfaction and a stimulus to further development.

The attitudes of employers toward registration are far from consistent. Some require that every man holding an engineering title must be registered, while others ignore registration except for those positions legally requiring it. Many employers have no specific requirements, but encourage their engineers to become registered as a mark of professional attainment. The engineer must judge whether his employer's attitude and his prospects for advancement justify registration.

If the engineer will need to be registered later, he should take the examination at an early stage in his career. The academic parts of the examination are easier to pass soon after graduation. Moreover, preparation for the registration examination is likely to be a useful phase in the engineer's technical growth.[5]

[5] Much of this material has been condensed from a booklet, *Professional Identification*, published by the Industry Training Committee, Detroit Area, Engineers Council for Professional Development. Copyright 1956: The Engineering Society of Detroit.

Summary

The joint responsibilities of educators, industry and the engineer discussed herein include: (1) selection of a job that matches the engineer's interests and qualifications; (2) a close relationship between the engineer and his supervisor, leading to a planned program of professional development; (3) continued education of both a formal and informal nature, designed to broaden the engineer's interests; (4) development of the management outlook; (5) participation in community affairs; and (6) professional identification.

Educators have the responsibility for creating an awareness of the factors contributing to professional growth and for instilling motivation in their students. Industry can encourage the young engineer by showing an interest in his efforts toward professional development and by giving him time and opportunity for some of these activities. The rest is up to the engineer.

TO STUDY COLLEGE PRESIDENCY

Work began January 1 on a study of the office of the college and university presidency. Harold W. Dodds, who retired as president of Princeton University in June of this year, will direct the study, with the support from the Carnegie Foundation for the Advancement of Teaching.

Dr. Dodds expects to look into the historical development of the office in the United States and the nature of the college president's job today. He will visit a number of campuses to talk with presidents, deans, and faculty members.

The Carnegie Foundation grant for the study was made to the Institute for College and University Administrators, in Boston. Robert W. Merry, director of the institute expressed the need for "systematic knowledge about the president's job." He added, "We have long hoped for the opportunity to sponsor a study such as the one Dr. Dodds will now make."

ENGINEERING SCIENCES—STILL ANOTHER LOOK

GENE M. NORDBY
Program Director

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Engineer

Program for Engineering Sciences, National Science Foundation, Washington 25, D. C.

By tradition and classical definition, the engineer is a practical individual whose work involves the art of balancing scientific principles against economic factors to produce a device, product, or structure for the benefit of mankind. The typical work of this engineer has required some knowledge, but many times "not too much" of the basic laws of science.

If additional data or facts have been required, the average engineer's reaction is to "run a test," either to some scale or on the actual device and use the resulting information without asking why. After all, these "data" permit the successful completion of the design, and the function of the engineer has been fulfilled.

The range of problems facing the engineer today, however, has become much more complex and sophisticated. "Yankee ingenuity" is no less important, but must for many problems be applied at a higher level. As the engineer works with new materials in new ranges of temperature and pressure, or attempts the design of new structural forms having new and complex uses, intuition and testing are not a sufficient basis for optimum success.

Current trends in engineering education, accordingly, are toward the emphasis of basic scientific knowledge and away from the classical "how to do it" courses. Graduate work in enginering at the M.S. level is becoming common, and the need for advanced work at the doctoral level for more engineers is becoming evident. Thus a trend which was followed by the so-called "pure sciences" of physics, chemistry, and mathematics many years ago is today appearing in engineering.

As a result of this earlier conversion of the pure sciences, however, there exists within those groups a strong tradition of basic research which in engineering is still in a formative stage. This transition period, a difficult and even painful one for many enginers, has resulted in confusion and conflict among members of the profession. Also, the existence of this growing trend has not yet been recognized by many members of the pure sciences fraternity, resulting in a sense of frustration and a defensive attitude on the part of some engineers as they attempt to assume a role as purveyors of basic research.

To be more specific, what is basic research in engineering and what is the impetus for the growing emphasis on the "engineering sciences"? In the classical sense, again, even the name "engineering science" is a contradiction to the old-line practitioner of an art, and from one important viewpoint the title of "applied science" is much more logical. Again by tradition, however, pure scientists who are applying their research to more practical problems hold a rather strong claim to that name. The engineer whose

work may also be in this area is neither accepted as an applied scientist nor, perhaps more important, does he wish to surrender his identity as an engineer.

Research performed by engineers may be as fundamental as any in the classic science fields. Since engineering research may well have originated in the attempted solution of an applied problem, however, this "feedback" will inherently orient research in the engineering sciences toward some specific area. This contrasts sharply with the classic concept of basic research being performed in a systematic but random manner, motivated only by the intellectual curiosity of the investigator.

One example of this feed-back process is radio astronomy, which stemmed from the original attempts of Dr. Jansky to secure information on the sources of noise and static interfering with transoceanic radio communications. In other words, the engineering scientist is less likely than the pure scientist to choose random areas of study, although his work in his chosen engineering area may with justification be described as truly fundamental or basic research.

A second incentive for the engineer's activity in basic research is his discovery that basic information is required in an area which has been essentially "abandoned" or neglected by one of the areas of pure science. This is exemplified in the current emphasis by the majority of physicists on studies in the nuclear areas, while many of the areas of classical physics which were not completely examined have been transferred to advanced workers in civil, electrical, and mechanical engineering.

Fluid mechanics, electromagnetic fields, heat transfer, thermodynamics, and properties of materials are among those areas in which wide gaps of ignorance still exist. These will require much additional expenditure of time and money before anything resembling a complete understanding can be secured. An example of this incomplete research is the lack of understanding about the semiconductor behavior of oxide-coated cathode materials; these properties have been almost completely ignored in comparison with the effort and time lavished on the transistor.

Another example from the field of fluid mechanics is the problem of boundary layer phenomena and their control. This area is of interest to almost all the fields of classical engineering, but both data and theory from the pure sciences are incomplete. This problem also illustrates a danger associated with excessive compartmentalization in engineering. While mechanical, civil, chemical, and aeronautical engineers are all interested and working in the area, too few of those in one field are aware of the publications and efforts of their colleagues in the others. In addition, all these workers are thoroughly ignorant of foreign activities, particularly Russian. Other areas with little or no theoretical basis for understanding and further work can be found; among them are turbulence in fluid flow, high rates of strain in materials, ion exchange in soils, catalysis mechanisms, and dislocation theory for crystalline structures.

The concept of engineering sciences has stirred considerable thought and more than a little heat within all areas of the profession, particularly among those in engineering education. Certainly, any changes in a long-established program should be accompanied by discussion and debate, but the changes must and will occur. Engineers and engineering must move ahead as rapidly as the technology which they seek to interpret.

For many years, the engineers' role has been to adapt pure science concepts to useful applications. But the level of the science to be interpreted has recently been rising at such a rapid rate that many engineers have been unable or unwilling to maintain the pace. (This may be an indictment of past engineering education, but is not the subject of the present discussion.)

Further, basic science does not respect artificial designations or compartments such as electrical, mechanical, or civil engineering. Many problems to be faced cut broadly across professional areas and require a breadth of knowledge not always within the conventional engineer's grasp. Filling this new higher-level role seems to have fallen to a person with a more nearly basic outlook–the engineering scientist–who may in time fill the position of interpreter between pure science and the larger body of the engineering profession. If so, he will do this both through utilization of new developments produced by the pure scientists, and through the filling of research gaps in the scientific spectrum which have been bypassed by pure science.

It would be presumptuous of the engineering scientist to say that all engineers must be made over in his likeness, but the inevitable effect must be a gradual raising of the level and accomplishments of those practicing the profession of engineering. This rise must occur or the profession will fall to the level of a technical trade, with its members grinding out solutions from handbook charts and tables. This nation, which owes so much to the engineers' contributions in the past, will therefore continue to look to the engineer for more and greater advances, which the profession has no choice but to provide.

PUBLICATIONS RECEIVED

1. *The Seventh Annual Report of the National Science Foundation*, describing the operations of the Foundation for the fiscal year ended June 30, 1957. (U. S. Government Printing Office, $1.00.)
2. *The 25th Annual Report of the Engineers' Joint Council for Professional Development*, available from ECPD, 29–33 West 39th Street, New York 18, N. Y. at $1.00.
3. *Engineering Careers in Canada*, published by the Engineering Institute of Canada, 2050 Mansfield St., Montreal 2, Quebec, provides detailed information on engineering opportunities in Canada.
4. *Federal Funds for Science*, a National Science Foundation publication, describes in number VI "The Federal Research and Development Budget, Fiscal Years 1956, 1957, and 1958." (NSF-57-24, U. S. Government Printing Office.)
5. *Costs of Attending College*, a study of student expenditures and sources of income, has been published by the U. S. Department of Health, Education, and Welfare. (Bulletin 1957, No. 9, U. S. Government Printing Office, $0.45.)
6. *Graduate Student Enrollment and Support in American Universities and Colleges, 1954*, has recently been published by the National Science Foundation. (NSF-57-17, U. S. Government Printing Office.)

ENGINEERING AND MANAGEMENT DECISIONS IN THE PORT OF NEW YORK AUTHORITY

AUSTIN J. TOBIN

Executive Director, The Port of New York Authority

This paper was presented as a luncheon address at the 65th Annual Meeting, Cornell University, June, 1957.

The history of The Port of New York Authority is in a very real sense the story of the application of engineering knowledge to the planning, financing, construction and operation of great public works in the New York metropolitan area. Created in 1921 by a joint compact between the States of New York and New Jersey, the Port Authority was directed to carry forward the future development of the public terminal and transportation facilities of the district. These included bridges, tunnels, waterfront terminals, airports, and consolidated public terminals for the handling of passengers and freight. The two States directed it, furthermore, to promote the flow of commerce through the Port and to represent the Port before the Congress and with the Federal transportation agencies.

In accordance with those directives, the Port Authority has financed and built facilities which represent an investment of about $700 million, much of it constructed at dollar values of fifteen and twenty years ago. So far this program has involved the marketing of over a billion dollars of Port Authority bonds, of which about $386 million are outstanding.

During the 36 years since that Port Compact was entered into by the two States, the New York-New Jersey metropolitan area has grown in population by more than 50%. Its economy, as measured by its industrial production, has increased more than fourfold. At the same time, there have been spectacular technological advances in manufacturing methods, in means of communication, and in transportation. Let me note only that the coming into widespread use of the motor vehicle and airplane, of radio and television communication, and mass production methods are all largely within this 36 year period.

These great changes have all had a revolutionary influence on the Port Authority. Whereas in the first twenty-five years of its existence the agency was one largely devoted to bridges and tunnels and railroad freight terminals, including such engineering achievements as the Holland and Lincoln Tunnels and the George Washington Bridge, the past ten years have marked the fulfillment of the comprehensive program of port development envisioned in the Compact of 1921.

In this short period the Port Authority has built or undertaken responsibility for marine terminal development along vast stretches of the Port's water front, has been given the responsibility for the continued development of the metropolitan airports, New York International, La Guardia, Newark, and Teterboro, and has built and operates the world's largest bus and truck terminals.

Definition

A word of explanation is perhaps in order about the nature of an authority. It is a public corporation set up outside of the regular framework of government departments, commissions, or bureaus and freed from the

procedures or restrictions of routine government operations, in order that it may bring the best techniques of private management to the operation of self-supporting or revenue-producing public enterprises.

There are several key points in that definition. Though an authority is a public corporation, it ordinarily has no power to tax or even to use the credit of its parent in borrowing money. Instead, it must support itself on the revenues of the public works which it constructs or operates, and must borrow on its own credit.

This requires the investors' confidence that there will be adequate operating revenues left to take care of debt service after all of the operating and maintenance costs have been met. Note also that the concept of operating with the efficiency of good corporate management carries with it the assumption that considerations of party politics cannot be tolerated in the management of well-run public authorities.

Organization

Our staff in The Port of New York Authority numbers 4,400, of whom 850 are in engineering and engineering-planning units. They are responsible, among other things, for a construction program exceeding $100 million a year. Because the engineering function is so important to our total effort, I think you may be interested in how we are organized for engineering.

The top policy-directing head of the Port Authority is a Board of twelve Commissioners, appointed by the Governors of the two States for overlapping six-year terms. The Commissioners serve as a public duty and without compensation and act in the same capacity as a board of directors of a private corporation. The accomplishments and reputation over the years for efficient and forward-looking public service have made the office of Commissioner of the Port Authority a post of high public honor and have attracted men of leadership and accomplishment in the metropolitan community.

The present Board includes distinguished representatives of the business world and the professions—including five graduate engineers whose professional scope spans the fields of construction, consulting engineering and engineering education.

Reporting to me, as Chief Executive Officer of the Port Authority, are four line departments: Aviation, Marine Terminals, Inland Terminals, and Tunnels and Bridges, representing the four types of transportation and terminal facilities for which we are responsible. Staff departments furnish service and assistance to the line departments and help me in my executive responsibilitiy of assuring top-level performance.

Each of the four line departments has a planning division to develop functional plans and designs for new facilities, as well as to assure their department directors that outside engineering services, whether within or outside the Port Authority, are performing on schedule, within the dollar estimate, and according to the functional plan. Of course, a majority of the personnel in these planning divisions are engineers.

Our Chief Engineer, through our central staff Engineering Department, has top responsibility for carrying forward the functional plans, for engineering design, and for the preparation of specifications from which outside contractors can bid and build. He has the prime responsibility of "dogging" the construction to assure conformity to plan, of inspecting and testing materials, and of getting the job done within the contract time.

The Commissioners and I look to him as our top engineering advisor within the Port Authority organization.

We have divorced maintenance engineering from the responsibility of the Chief Engineer, and have placed it in the hands of a central staff agency which we call the Operations Services Department. This group has responsibility for a varied assortment of specialty engineering, including establishment of maintenance standards, maintenance research and development, industrial engineering including estimating the costs of operating and maintaining planned facilities, and by no means least, safety and inspection.

We have a firm policy that our internal or staff engineering must be competitive with the cost of comparable engineering services on the outside. To this end we maintain a complete and detailed set of cost records and controls. We never hesitate to go outside the organization for engineering services where this would seem to be of economic advantage. Outside services are of course particularly helpful in furnishing special talent or experience, and in meeting peak requirements, thus stabilizing our work force. During the past year, the amount paid by the Port Authority for outside engineering services exceeded a million dollars.

Engineering

As you can surmise even from this outline, the Port Authority has been continuously and heavily dependent upon the Engineer: from the initial conception of the Port Authority's work in 1921—an engineering design of a belt railroad to serve the port—to its most recent achievement only a few weeks old—the construction of the third tube of the Lincoln Tunnel.

Initiation and development of a Port Authority project calls for the simultaneous effort of many skilled specialists and the business judgments of many experienced executives all working in harmony to produce the final product—a policy decision implemented by appropriate action. The engineer is a fundamental and continuous contributor to the final result. His contribution commences in the field of research and development, goes on through the study and evaluation of functional plans, and must be constantly at hand during their economic analyses. Then he must, of course, design, write the specifications, and participate in the writing of the contracts, evaluate the bids, and supervise every detail of the construction.

All of this calls for a restless scientific curiosity and imagination, for engineering minds that are forever unsatisfied, open, and flexible. It calls for engineering energy and for youthfulness of spirit, to dump all of yesterday's hard won plans into the wastebasket, and start all over again, facing new facts and new problems and using or inventing new techniques.

Let me give you a dramatic example of this in an engineering project of vast scope. Only three years ago, after an equal period of very hard functional planning and engineering design, we had brought to completion, so we thought, the plans for the Terminal Building and Central Terminal Area at New York International Airport.

The traffic estimates had been carefully prepared and were concurred in by all of the airline users. The plans had been developed in cooperation with the airline tenants and had their general concurrence. They called for the largest airline terminal building in the world, and included basic requirements and functional arrangements that had been tried and tested, not

only by ourselves but by all of the leading airport designers of the world.

All of these functional plans had been prepared under the direction of the engineer and architect who is the Chief of our Aviation Planning, Mr. Thomas M. Sullivan, perhaps the foremost airport architect and engineer in the world. Just at about the time these plans were being brought to completion, and with hardly any warning, we were confronted with a break-through of whirlwind proportions in travel forecasts. New figures and new thinking in the estimating of future passenger loads, made it devastatingly clear that even the largest single airport terminal building ever designed would not be able to handle the 9½ million passengers projected for this one airport by the year 1965.

These estimates were complicated by accelerated technological developments in the design of jet transport planes. With these new estimates accepted both by our own Aviation Department and by the airlines, Mr. Sullivan figuratively gathered up all of those fine plans for the world's largest single terminal building and dumped them in the wastebasket.

He and our staff then had to go to work again on a blank page. Their utterly new and fantastic problem was not eased by the fact that our temporary quonset hut terminals were horribly inadequate, that the public was impatient for the construction of modern terminal facilities, and that some politicians who knew nothing of the problem, and cared less, were more than eager to criticize.

Mr. Sullivan's response has been a completely new concept in airport terminal planning that will open for passenger operations at New York International Airport next month. Striking out into bold new patterns of passenger handling and air terminal functioning that had never been thought of before, including a Central Arrivals Building and a great circle of unit terminals, designed to sort, handle, and expedite the flow of both overseas and domestic passengers at what will be the world's busiest airport, this imaginative architect has come up with the airport pattern and model of the future. This is what I mean in my plea for young engineering minds that are forever unsatisfied, open, and flexible.

It is this same restless and ever curious type of engineering mind which has now made it possible for us to use steel piling for our new piers in New York, with a highly favorable economic result. The application of cathodic protection for the steel members gave us that answer. Again, our mechanical or electrical engineers may design a new appliance, or a new technique to maintain or operate a given facility more economically—be it a 21-ton emergency truck designed to traverse sand and throw huge quantities of foam and water to extinguish fires and save lives at an airport, or a baffle scrubber to keep tidy the interior of an under-river tunnel, saving thousands of man-hours over hand cleaning.

I suppose that everyone who has ever discussed this subject has emphasized the need for training in the art of communication; the plea of management for young engineers who can write a clear and concise report in layman's language or express themselves in a staff meeting. Every turn of engineering work in the Port Authority, as in any other organization, involves presentation to, review by, and discussion with management. Here the ability of your graduates to express themselves, to use the English language, is their very passport into the corporate world.

Requirements

One of the most important attributes of a successful engineer in the Port Authority is his ability to see his problem in its proper perspective in the over-all organizational requirements. If he cannot do so, he is not likely to succeed in getting his point of view accepted. Preliminary designs coming up from the Port Authority's Engineering Department or from the planning sections of the line departments are submitted to the most extensive staff review and criticism, from the standpoints of operations, maintenance, cost and public acceptance.

If the engineer is to play his proper part in these critical considerations of his project, he should have training in business management and financial practices. Otherwise he may not be able to grasp and grapple with the diverse requirements of a practicable and successful engineering project. For a hangar to be structurally sound and of advanced design is of little value if we cannot, because of the high cost of construction, find tenants to lease it.

His sense of economics should give him also an appreciation of the fact that even in engineering there is a time and a place for everything and for many standards. The design criteria applicable to the construction of a great vehicular bridge or tunnel have no application to the construction of industrial buildings which must pay out in twenty years or less. One is built for the ages and the other to earn a quick commercial return. Both require skilled engineering, but the engineer who confuses one with the other, through an inability to discriminate in the field of economics, is headed for failure.

I speak of this with some feeling because we ourselves suffered some years back through a series of structures that were over-designed or were otherwise inappropriate for their intended use. Throughout the early history of the Port Authority our engineering had been confined to the design and construction of public bridges and tunnels and their approaches—monumental structures built to last for a hundred years or more, where all allowances for error should be made on the side of safety and security.

The engineering transition to truck and bus terminals which were supposed to pay their own way, and then to hangars and small industrial buildings, has been painful. A granite base course added nothing to the financial return of a truck terminal and could hardly be justified as even aesthetically desirable. And an ornamental brick wall overlooking a swamp on the back of a terminal building was only calculated to incite carnage and mayhem between the Comptroller and the Engineer of Design. Of what use is a plan for a small manufacturing building which cannot compete in cost per square foot with the general run of plants manufacturing the same product?

Business and economic problems such as these finally led us to a reorganization that placed the responsibility for defining functional requirements upon the line departments, which carry the net revenue responsibility in their respective fields of aviation, piers and docks, bus and truck terminals, and bridges and tunnels. While on the face of it this might seem to release the engineer from the responsibility for worrying about the relationship of non-engineering factors, nothing of the sort has occurred.

Though ultimate responsibility for the definition of functional requirements may rest with his client—in our case, the line department—we find

that the engineer nevertheless brings to bear the full weight of his craftsmanship, his experience, his professional judgment, and his professional pride. He frequently, in fact usually, suggests alternative schemes, and quickly reflects his client's keen appreciation of the business and economic objectives.

Interestingly enough, the functional designer, in the line department of the Port Authority, is often an engineer himself, frequently a graduate of the Chief Engineer's own department. This serves to push out the effective frontiers of engineering influence beyond the borders of the Engineering Department itself.

Breadth of View

Because the engineer cannot do the whole job himself, but must rely on the efforts of many others in the development of a project, the need for a basic understanding of management and the underlying principles of getting work done through others is critically important to the effectiveness and success of an engineering career. In the absence of this knowledge or faculty the engineer is unable either to produce an effective product or to secure its acceptance.

For example, our Chief Engineer is himself the top manager of a force of 340 in his immediate department, a not inconsiderable staff to supervise and for which to be held responsible. To deal successfully with a staff of this size and diversity, including designers, resident and field engineers, architects, draftsmen, inspectors, chemists, laboratory technicians, stenographers, filing clerks, and chauffeurs, an engineer must understand all that modern management has to teach in terms of planning, organizing, and integrating the efforts of others.

If the Chief Engineer and his division chiefs expect to meet scheduled project completion dates, stay within budgeted cost estimates, and adequately motivate their own staffs, they simply must keep up with modern management concepts. So too, if the product, be it a design or a final contract plan, is to be accepted or executed, he must understand how to deal with his staff associates on the legal, financial, and administrative sides. This is equally valid whether the relationship is between the Chief Engineer and General Counsel, for example, whether it is between the Engineer of Design and the Chief of the Insurance Division of the Comptroller's Department, or on any level of supervisory responsibility among the engineering group and their corporate associates in other departments.

For the engineer-manager to serve effectively as spokesman for his Department, he must be able to understand the requirements of his specialist associates, make them in turn understand the elements of the engineering problem or concept, and be willing to modify these to meet the needs of the organization as a whole. This in turn entails a deep understanding of the organization and functions of the enterprise, and of the inter-relationships between its component parts.

The young engineer going into corporate or consulting work—by which I mean to indicate simply "inside" or "outside" engineering service—should be prepared in his training for his role as a specialist retained to perform a *service* for a client. It is his job to meet the client's requirements and advise him as to the engineering aspects of his problems, and not to attempt to take over the management of the project. He must satisfy his client—his customer—and not try to take over his customer's business.

One of the most brilliant and for a

time successful lawyers that I ever knew lost his entire practice, one client after another, by assuming management prerogatives and responsibility beyond the call of his legal services. The engineer may and should guide and advise within the scope of his professional expertise. But his clients—in the Port Authority, the directors of the line departments—must make their own net revenue decisions as to the economic practicability of projects entrusted to them, after listening to the advice of their engineers.

If these decisions are so bad that the engineer no longer wishes to be associated with them he should, in the case of a consulting engineer, look for a new client. An "inside" engineer should seek his recourse within established corporate channels. Here again we come back to the necessity for an understanding both of management procedures and the art of human relations.

Humanities

An engineering manager who understands his own specialty and even the specialties of the other disciplines in our organization, but who fails to understand people and how to get along with them, will be relatively ineffective. Molding the diverse requirements of government, public relations, financial demands, legal considerations, and operating requirements into one unified "management policy decision" calls upon each of the participants for a high degree of knowledge and ability in getting along successfully with their associates.

Some engineers are rated as "rigid" and "stubborn" by their staffs. While this undesirable attitude may be only a superficial mannerism, it may hamper the acceptance of the individual's point of view in staff meetings or, if he is a consultant, his resource of knowledge may be rarely sought. A good deal of this lack, where it appears, seems to be as much the product of an individual's home and social background as of what he has learned in the formal disciplines of the classroom.

In this connection I think that you are to be congratulated for the time that is being devoted in our engineering colleges today to the social sciences and the humanities, particularly since I recognize the urgent pressures upon you for the pre-emption of every available classroom hour by your technical subjects. This policy will guide your graduates toward a better understanding of the viewpoints and problems of others, and so enable them to adapt their engineering knowledge to the total needs of an organization. Our own top engineers tell me that this policy of devoting more than 20% of your available time to the humanities is already having its effect and can be discerned in the engineering graduates coming to us today.

The successful engineer in our organization, more perhaps than any other single attribute, most possess a broad rather than a narrow point of view. He starts with a thorough grounding in the objectives of the organization, as well as of his own specialty. He carries forward this emphasis on the corporate objective to each project on which he is engaged. The broader the scope of the engineer, the more likely he is to succeed in administrative jobs that are somewhat removed from his technical specialty.

We have devoted a good deal of thought and effort to assist our engineers in this broadening process. Measures we have taken include special management training courses both within and outside the Port Authority, staff development conferences and programs, an intensive communica-

tions effort that includes a veritable barrage of publications and special assistance, and a deliberate effort to throw the enginer together with his staff associates through a wide gamut of professional and social meetings, conferences and interchanges.

As I review the roster of our own top staff, I am not surprised to see that some of our most important executives were originally trained and educated in engineering. Included in this group are our Director of Aviation, our Director of Port Development (who is our top planner) and his Executive Assistant, our Deputy Director for Comprehensive Planning, and our Deputy Director of Real Estate. Each of these executives has added to his basic engineering background and training a wider and rich background of other disciplines.

Conclusions

If I have centered on what appear to me to be some of the gaps or deficiencies in engineering training as I see it reflected in the Port Authority, let me hasten to cite some of the aspects of that training that appear to place the engineer at an advantage over his associates. Most of our engineers seem to approach each problem in a highly analytical manner, to assemble and relate facts, to select and use those that are important and to discard the irrelevant.

Such men take nothing for granted; they reflect what we call "the questioning attitude." In the solution of the problems with which he is confronted the engineer tends to apply himself directly thereto; this may account for his somewhat direct manner in dealing with others. His basic emphasis on the "why" has helped fit him for some of our newly opening non-engineering fields such as operations research.

Ultimately, the engineer's future is determined by his own interests, his ability to work with and understand others, his ability to lead and motivate, his versatility, his knowledge and use of new ideas and materials, his judgment, his understanding of basic management principles, and his ability to convey his knowledge and skills to his associates. How much of this can be incorporated, to the extent that it is not now, in our college engineering curricula, I leave to you who know so much more about it than I shall ever know.

FLORIDA DOCTORAL PROGRAM IN ENGINEERING MECHANICS

A graduate program in Engineering Mechanics, leading to the degree of Doctor of Philosophy, has been announced by Dean Joseph Weil of the College of Engineering, University of Florida at Gainesville.

The doctoral program in Engineering Mechanics is a response to the increasing emphasis on engineering science in professional training as opposed to education for a special field, according to William L. Sawyer, head professor of Engineering Mechanics.

The Department of Engineering Mechanics of the Florida College of Engineering has been offering the masters' degree with a major in Engineering Mechanics for the last 10 years.

A Brief Report and Evaluation of

CLOSED-CIRCUIT TELEVISION INSTRUCTION IN MECHANICAL ENGINEERING

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During the fall of 1956 an experiment in teaching a junior level course in mechanisms (M.E. 360) by television was conducted at Purdue. The experiment was a joint project of the School of Mechanical Engineering, the TV Production Unit, and the TV Program Research Unit of the Audio-Visual Center. This report is concerned with an examination of student achievement during televised instruction and with student reactions to the use of television in the classroom. The data were gathered throughout a sixteen-week semester.

A word of caution concerning interpretations is in order. A single, limited study which involves only a relatively small sample of students and instructional techniques is not an adequate basis for broad generalizations. Also, a study of this type can be no better than the criteria it employs as the means of measuring outcomes. The criteria used in the present study, i.e., the achievement and attitude measures, are no more than barely adequate and are certainly not ideal.

Conclusions

The study suggests the following conclusions:

1. Student achievement was the same, for all practical purposes, under televised and conventional instruction conditions.

2. An item-analysis comparison of the responses of TV-taught and conventionally taught students on the 28-item criterion test revealed that there were at least slight response differences in favor of the conventionally taught group on 19 items. Similar differences favored the TV group on 9 items. Six of the observed differences were statistically significant, five favoring the conventionally taught group, one favoring the TV group. Items differentiating the groups formed no noticeable patterns.

3. Student attitudes toward televised instruction were no more than midly negative prior to experiencing such instruction. Through exposure, students were somewhat less favorably impressed by certain aspects of such instruction.

4. Pre-test to post-test response changes were significant on five of the ten items contained in a student questionnaire. In each case, post-test responses indicate less favorable attitudes than did the pre-test responses. Items on which changes occurred concerned (a) the instructional value of TV lectures, (b) the interest-capturing and interest-holding power of TV instruction, (c) note-taking during televised instruction, (d) student inclination to prepare for TV class meetings, and (e) general acceptance of TV as an instructional medium.

5. Students appeared most disturbed by the following aspects of TV instruction: (a) the interest which it can capture and hold, (b) the inability to discuss questions with the instructor, (c) opportunities to take notes in class, (d) lack of opportunity

to become acquainted with the instructor, and (e) their inclination to prepare for TV class meetings.

6. "Favorable" responses are most numerous, though not necessarily in the majority, on items concerned with (a) the instructional value of TV demonstrations, (b) student *comfort* during televised classes, (c) classroom discipline, and (d) general acceptance of television as an instructional medium.

7. Discipline in the television classroom apparently is not a serious problem. Before TV instruction, students were almost evenly divided on the question of whether discipline would be a bigger problem in TV classes than in conventional classes. No significant response change occurred as a result of their experience with television instruction.

Plan of the Study

The course which served as a basis for this study is Mechanical Engineering 360, a junior-level course in mechanisms. It is normally taught by means of two 50-minute class meetings and one three-hour laboratory meeting per week. Class meetings are conducted by a senior staff member and involve a student group ranging in size from 20 to 30. Laboratory meetings are usually directed by a graduate assistant and involve the same number of students. Satisfactory completion of the course requirements entitles the student to three semester hours of credit.

Experimental Conditions. Two instructional situations (TV and conventional) were under investigation. The main hypothesis to be tested was this: Student achievement, as measured, is not significantly affected by the differences of these two specific instructional conditions.

One group of 37 students received conventional instruction throughout the semester, attending both class and laboratory meetings under conventional conditions. They were taught as two sections or divisions, one of which was under the direction of the instructor responsible for televised instruction. A second group, composed of 46 students in two classrooms, received the non-laboratory portion of the instruction via television. Laboratory instruction for this group was conventional.

The TV students met in standard classrooms with maximum seating capacities of 40 to 50 students. A 24" television receiver, mounted so that the center of the screen was approximately six feet above the floor, faced the class from the corner of each room. In response to student wishes, a telephone was installed in one of the classrooms for student use in asking questions. This system of communication has obvious shortcomings and at last report had been used once to ask the question, "Will we be tested over the material covered today?" A single graduate-assistant was responsible as proctor for the routine aspects of classroom administration in both television classrooms.

The Students. Sixty-four of the student subjects, or 77%, were studying to become mechanical engineers; 16, or 19%, were studying to become aeronautical engineers; three, representing 4% of the group, were students in some other field. Seventy-nine per cent were first semester college juniors, 3% were sophomores, and 19% were either last-semester juniors or first-semester seniors. All but two students in the TV group reported their ages; the average was 22.02 years, the model (20 out of 44) was 20 years.

Orientation test scores for 68 of the 83 students (all the scores that could be located) showed that the average raw score on the Purdue Mathematics

Training Test (Form Bm) was 52.2. This score would correspond approximately to the seventy-eighth percentile. On the *Purdue Placement Test in English* (Form B) the average raw score was 137.1, corresponding approximately to the seventy-third percentile. In both cases, Purdue freshman norms were used.

Criteria. Two types of criteria were used in the evaluations to follow. First, student achievement was measured by a 28-item [1] multiple choice test, devised by the instructor responsible both for the TV class and for one of the two conventional classes. This test was administered, unannounced, just prior to the end of the semester.

Both TV classes took the test during the same class period. The two conventional class sections took the test later, two or three days after the TV group. Students knew the test was not their final examination, but were warned that their performance would be one factor considered in assigning semester grades.

The "internal consistency reliability estimates" (K-R formula No. 20) for the test were low. They are: for the TV group, 0.485; for the conventional group, 0.365; for the groups combined, 0.435. Pearson "product-moment correlation coefficients" involving the 28-item criterion test and other measures are presented in Table 1.

Table 1 shows that the 28-item test score bears a significant, positive relationship to cumulative grade-point index and to the average score on the tests which served as a primary basis of semester grades in M.E. 360. The correlation of 0.468 between the 28-item test scores and the average scores on the other class tests is at, or near, the upper limit to be expected, in view of the estimated reliability of the former measure.

[1] The test, as administered, contained 30 items. Two items had more than one correct answer and were eliminated from consideration.

TABLE 1

MATRIX OF CORRELATION COEFFICIENTS*

Variable		Variable (5)	(4)	(3)	(2)
Cum. gr. pt. index	(1)	.133[a]	.323	.516	.335
28-item test score	(2)	.270	.027[a]	.468	
Avg. M.E. 360 score	(3)	.144[a]	.121[a]		
Purdue Mathematics	(4)	.338			
Purdue English	(5)				

* Correlations 12 and 13 based on 83 cases, others on 68 cases.

[a] *Not* significantly different from zero at .05 level.

The second device used in evaluating the results of the experiment was a short questionnaire of ten items (see Table 5). This was given to the TV group both before and after the semester's instruction. It was not administered to the conventional sections; however, it may be assumed that the initial responses of the conventional group would be essentially the same as those of the TV group and that the former would not change significantly during the period of conventional instruction.[2]

Findings

Student Achievement. "Single classification analysis of covariance" [3] was employed to test the main hypothesis, i.e., to ascertain whether student achievement was influenced by the two specific conditions of instruction. In performing the analysis, the two instructional conditions served as the classification variable, the cumulative grade-point index as the predictor or

[2] See *A Brief Report and Evaluation of Closed-Circuit Television Instruction in Physics 230/240,* (Mimeographed), pp. 10-11. Purdue University, Audio-Visual Center, 1957.

[3] Walker, H. M., and Lev, J., *Statistcial Inference,* New York, Henry Holt and Co., Inc., 1953, pp. 387–406.

TABLE 2

INFORMATION CONCERNING PREDICTOR (CUM. GR. PT.) AND CRITERION (28-ITEM TEST) SCORES

Information	Group		
	TV	Conv'l	Total
Cum. gr. pt. avgs.	4.235	4.296	4.2622
S.D., cuml. gr. pt.	.625	.537	.585
28-item test avgs.	15.000	15.838	15.374
S.D., 28-item test	3.197	2.764	3.023
Correlation, c. gr. pt. and 28-item	.438	.152	.335
No. of cases	46	37	83

covariate, and the scores on the 28-item achievement test as the criterion or dependent variable. In Table 2, information concerning the predictor and the criterion are presented.

Table 2 shows that the average cumulative grade-point index for all 83 students was 4.262, slightly above the grade of "C". It further shows that the TV and control groups are not identical with respect to past academic performance, the latter group having earned grades slightly higher than those of the TV group. Because the criterion test is significantly and positively correlated with the cumulative grade-point index, we should thus expect the two groups *not* to score identically on the 28-item criterion test. The effects of grade inequality must be allowed for in order to test the effects of the two different conditions of instruction upon student achievement.

(1) *Test of the Main Hypothesis.* Results of the analysis of covariance are presented in Table 3. They show that, on the 28-item criterion test, eliminating the initial differences between the two groups, there is a 0.734 point difference between the group average scores, the conventionally-taught group making the higher average score. Since the obtained F ratio of 1.345 for this difference is not statistically significant at the 0.05 level, i.e., has a probability greater than 5 in 100 of having arisen by chance, it must be concluded that the observed difference is no greater than might be expected to occur by chance, and does not represent a reliable difference between the two groups. The main hypothesis is therefore sustained.

(2) *Item Analysis Comparisons of TV and Conventional Groups.* In addition to the analysis of covariance just reported, a further check of student performance on the 28-item criterion test was carried out. The purpose was to uncover unique patterns of achievement which might differentiate between the two groups.

The steps of the analysis were as follows: (a) The test response information from the two groups was separated and a count was made of the persons in each group who answered each item correctly, (b) The counts of correct response were converted into percentages of the groups

TABLE 3

RESULTS OF THE ANALYSIS OF COVARIANCE

Source of Variation	df. before adj.	ΣX^2	ΣXY	ΣY^2	Adj. ΣY^2	df., adj. ΣY^2	Reduced ΣY^2	df., Red. ΣY^2	$MS_{Y \cdot X}$	$F_{Y \cdot X}$	"p"	regr. coef.
Between Groups	1	.0774	1.0555	14.3947	—	—	11.0001	1	11.0001	1.345	>.05	—
Within Groups	81	27.9648	47.5273	735.0270	654.2524	80			8.1780	—	—	1.70
Total	82	28.0422	48.5828	749.4217	665.2525	81	—	—	—	—	—	—

Adjusted Y mean, TV = 15.046 Adjusted Y mean, conventional = 15.780.
Difference in adjusted Y means = 0.734.

TABLE 4

ITEM ANALYSIS COMPARISON OF TV AND CONVENTIONAL GROUPS

Item No.	% Correct Responses		Omega Value	Item No.	% Correct Responses		Omega Value
	TV Grp.	Conv. Grp.			TV Grp.	Conv. Grp.	
1	63	84	.34	15	77	3	.12
2	39	43	.07	16	78	84	.10
3	76	65	.17	17	67	54	.20
4	28	38	.17	18	70	62	.11
5	87	95	.21	19	80	89	.18
6	43	32	.17	20	61	78	.27
7	76	84	.15	21	43	46	.03
8	57	76	.29	22	63	78	.24
9	91	84	.14	23	33	38	.08
10	37	49	.18	25	37	32	.08
11	33	11	.39	26	67	51	.23
12	37	38	.01	28	15	16	.02
13	28	35	.11	29	22	38	.26
14	83	95	.28	30	78	86	.17

from which they came, (c) The Lawshe-Baker nomograph for Omega [4] was used to obtain a value representing the significance of the difference between two percentages, (d) Each obtained Omega value was compared with that value necessary for statistical significance at the 0.05 level.

Table 4 presents the percentages of correct response in each group to each item and presents the Omega value to be associated with the obtained difference in percentages. An Omega value of 0.26 or larger is needed (for the present sample) in order to achieve statistical significance at the 0.05 level. Six of the obtained Omega values (for items No. 1, 8, 11, 14, 20, and 29) are 0.26 or larger. One of these values (for item No. 11) shows a significant percentage difference favoring the TV group, whereas the remaining five favor the conventionally-taught group. Examination of the content of items favoring one or the other of the two groups fails to reveal any obvious pattern differentiating the two groups; however, there is a tendency for the TV groups to do well on items dealing with gears and gearing while the conventional group did well on items dealing with linkages.

Student Attitudes. A ten-item questionnaire was answered by the TV group both before and after the semester's instruction. Responses to this questionnaire are presented in Table 5. In examining the distribution of responses reported in Table 5, an interesting reaction should be noticed. Students almost unanimously denied that TV instruction was as interesting as classroom instruction, denied that they would be inclined to do more homework for a TV class than for a conventional class, denied that they would get to know their instructor as well as they might in a conventional class, denied that they could take better notes than in a conventional class, and almost universally lamented the lack of opportunity for discussion during class time.

On the other hand, approximately half of the students believed that the televised demonstrations were as valu-

[4] Lawshe, C. H., and Baker, P. C., "Three aids in the evaluation of the significance of the difference between percentages," *Ed. and Psychol. Meas.*, Vol. 10, No. 2 (Summer, 1950), p. 267.

able instructionally as those in conventional teaching. Approximately half of the group felt that classroom discipline was *not* a bigger problem than in conventional classrooms, and one third of the group tended to disagree with the idea that television has no place in the classroom.

Each significant response shift reported in Table 5 is in the direction

TABLE 5

ATTITUDE ITEMS, RESPONSE PERCENTAGES, AND RESPONSE CHANGE FOR TV GROUP

Item	Response	TV Group		Response Change
		Pre-test	Post-test	TV Grp.
1. A televised classroom lecture does not instruct as well as the "conventional" classroom lecture.	Agree or prob. agr. Disagree or pr. dis.	59 41	81 19	Significant
2. A televised classroom demonstration (of materials, procedures, etc.) instructs as well as the "conventional" classroom demonstration.	Agree or prob. agr. Disagree or pr. dis.	59 41	44 56	Not sig.
3. Instruction received over classroom television does not capture and hold student interest as well as instruction received in the "conventional" class.	Agree or prob. agr. Disagree or pr. dis.	41 59	93 7	Significant
4. Students are more comfortable, more at ease, when receiving televised instruction than when attending a "conventional" class.	Agree or prob. agr. Disagree or pr. dis.	77 23	79 21	Not sig.
5. The inability of students to discuss questions with the instructor during class is a serious limitation of TV instruction.	Agree or prob. agr. Disagree or pr. dis.	89 11	98 2	Not sig.
6. Students can take a better set of notes when attending TV classes than when attending a "conventional" class.	Agree or prob. agr. Disagree or pr. dis.	43 57	12 88	Significant
7. Students who attend a TV class do not get to know their instructor as well as they might if they attended a "conventional" class.	Agree or prob. agr. Disagree or pr. dis.	91 9	91 9	Not sig.
8. Students who attend a TV class will be inclined to do more homework and extra reading than those who attend a "conventional" class.	Agree or prob. agr. Disagree or pr. dis.	25 75	7 93	Significant
9. Classroom discipline is a bigger problem in the TV classroom than in the "conventional" class.	Agree or prob. agr. Disagree or pr. dis.	64 36	53 47	Not sig.
10. Television may be all right for entertainment, but it does not belong in the class room.	Agree or prob. agr. Disagree or pr. dis.	36 64	67 33	Significant

of decreasing acceptance of TV instruction. While such decreases are easier to achieve than increased acceptance of TV teaching, such attitudes have been reported elsewhere.[5] This suggests that student reaction to television instruction includes feelings about the appropriateness of the subject matter for such presentation, plus reactions to the instructor and reactions to his success in shaping his presentation to the demands of this unique teaching situation.

Discussion

This study was undertaken to shed light on two rather specific questions. First, it was asked whether M.E. 360 instruction would be as effective on television as in the conventional classroom situation. Second, it was asked what the students' reactions to televised instruction in M.E. 360 might be.

In answer to the first question, it may be said with little fear of contradiction that the television-taught students learned, on the average, as much of the course content as their conventionally-taught counterparts. Not only does the evidence from the brief, definitely fallible criterion test support this conclusion, but scores earned on the tests used as a primary basis for assigning student grades suggest a very slight *superiority* of the TV sections. These classroom tests were not used as criteria in the main analysis of the study because, although all tests given were similar, they were not identical and thus could not serve as an adequate basis for careful comparisons between groups.

In answer to the second question, concerning student reaction to televised instruction, it seems apparent that the majority was not pleased with it. The many comments on the questionnaire completed by the TV-taught group may contribute toward a better understanding of student reasons for feeling as they did about TV instruction. A very frequent comment was that the picture on the TV screen was so frequently changed that not enough time was allowed for adequate absorption of important visual material presented on the blackboard or elsewhere.

More effective instruction and more favorable student reaction may result from presentations which are individually longer than those of much of the present course. The variety of visual stimuli presented through frequent changes of the picture is, in many cases, less desirable from the standpoint of student learning than a presentation which allows students sufficient time to absorb its meaning.

[5] Miami University, *Experimental Study in Instructional Procedures*, Oxford, Ohio, 1956, p. 32.

NEW HOME FOR BROOKLYN TECHNICAL SCHOOL

Polytechnic Institute of Brooklyn relocated this fall in quarters facing Brooklyn's new Civic Center. The site, just five blocks from the red brick buildings where the Institute has held classes for 103 years, was formerly the industrial plant of the American Safety Razor Company. Nearly 6,000 graduate and undergraduate students entered September classes in the remodeled buildings, where instruction and research equipment has been installed in modern laboratory facilities.

GENERAL EDUCATION AND THE LAW OF INCREASING ENTROPY

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It is no mere metaphor to say that the law of increasing entropy—or something very like it—operates on the accumulated knowledge of each one of us, and especially on that portion of our knowledge which is general rather than specialized. The facts of history, the plots and characters of fiction, even the ideas of philosophers, grow blurred and may vanish altogether. Language skill, painfully built up, often dwindles until nothing useful is left.

Even the discipline acquired in mastering subject matter has a way of growing soft and flabby. Critics of General Education may well ask, "If this stuff you deal in is so perishable a commodity, why should we pay so much for it? If it is so easily lost, what evidence do you have that it is at all useful?"

These questions, it would seem, require an answer; and the answer requires some re-thinking of both ends and means. The fact of forgetting, and it is certainly a fact, is the one thing which is most studiously ignored in most considerations of programs and objectives. Yet it is a problem of major importance in the design of curricula. If we face up to it, we may even learn something about what General Education is, what it is good for, what is essential in it, and how it should be organized and presented.

It is probably superfluous to spend any time making a "case" for the humanities. "Cases" have been made so many times and so forcefully that we should be able to begin with the *premise* that the humanities and social sciences deal with the most central concerns of mankind. In the broad view the humanities are useful, not in the achievement of specialized objectives, but in the business of leading a human life among other human beings.

But this pious premise is pointless if, in fact, the humanities are lost, forgotten, or never used. If general education is *potentially* useful, our problem is how to build courses and programs in such a way that the intellectual energy which is built up will not be lost for use or frittered away in meaningless activity.

Three suggestions—all of which check rather closely with the principles of the report on *General Education in Engineering*—may provide some guidance in teaching and curriculum planning. They are:

1. That we make sure that what we are teaching is really *general education;*
2. That we make sure that what we are teaching has *significant structure;* and
3. That we recognize the need for continuing use—or, to change the metaphor, *continuing nourishment*—and that we teach with this objective in mind.

At first glance it may seem superfluous to emphasize the need for making our courses really general education. We in engineering colleges have one advantage. We have a lot less time than our colleagues in liberal arts colleges. We are therefore under powerful pressures to stay on the

main highway and not wander off on intriguing but specialized byways.

It appears that we will always have this advantage. The eight-course sequence which the report on *General Education in Engineering* recommends as a minimum is very close to being a maximum, at least if we exclude from it strictly skill and professional courses. We are therefore restricted and limited in a way which is probably on the whole good.

But for most of us this limitation is still no assurance that we will stay on the main road. We were all trained as specialists in our subject matter. Our knowledge is, therefore, a specialist's knowledge, and we are inclined to feel that anything less than specialization is unworthy of our own scholarship.

Here the principle which has just been stated is particularly pertinent. We have said that general education seems to be more subject to decay than specialized education. If we will look very closely at our own experience, we will certainly discover, however, that it is *not true* general education which is lost but specialized education which the non-specialist did not need.

Unfortunately, much that we think of as general education is really this specialized education, taught to non-specialists, who promptly and thoroughly forget it. As an English teacher, I remember certain plots and characters, mostly because I am constantly using the books in which they occur. This for me is specialized knowledge, technical knowledge, if you like. It survives in me because it is narrowly useful, economically useful under my present circumstances. There is no reason why it should survive in my students, at least in the same form.

This does not mean that there is no point in having my students read these books. It does mean that knowledge of certain facts about these books is *not* the essential thing which I want my students to take away with them.

When I first started teaching, I was presented with a list of writers which a committee of the department had decided should be known to all students. Each student was to give an oral report on one of these men, and be prepared for an examination on all of them. What surprised me was the fact that there were at least five names on the list I had never heard before—and I had already passed my orals for the doctorate in English.

If this was knowledge of my specialty which was not required of me even as a specialist, I could not see why my engineering undergraduates should be expected to acquire it. I doubt whether any of them remembers anything about these writers today.

The general education these students were supposed to be getting was definitely *not* general. This illustration, I hope, is a particularly bad one, but I imagine it could be matched or at least approached in other courses.

In the limited time we have for the humanities and social sciences, the first necessity is to make sure that what we are teaching is really what the non-specialist, the non-major, the intelligent layman should know. If we concentrate on general concepts and principles, and on experiences which make these concepts meaningful we will have plenty to do; but what we do will be more useful, more permanent, less corruptible.

Turning now to the second point, the need for significant structure, we are facing one of the most controversial problems in general education, that of integrating our subject matter. The report on *General Education in Engineering* favors integration in

somewhat qualified language, as befits a committee report.

The value of integration, whatever kind of integration it is, lies chiefly in its ability to provide significant structure to what is learned. If that structure can be provided in other ways, then integration, coordination, or whatever we call it, may not be bad, but is probably superfluous.

Once more we come back to the principle behind this paper. Knowledge, we have said, tends to disintegrate. But the more significant structure it has, the better integrated it is, the more resistant it is to *dis*integration. This is not just a play on words. The reason much information escapes from us is that it is not tied to anything else. Isolated facts survive, if at all, only as curiosities.

The possession of significant structures, however, makes possible the reacquisition of facts and ideas which have been temporarily lost. If you know the derivation, it does not matter too much if you forget the formula itself. Facts which are part of an understood pattern either remain intact or are readily recoverable. Furthermore the process of recovering facts, of re-fitting them into the pattern, reinforces the pattern itself.

It does not follow from this that all ideas must be reduced to one basic structure, that we must concoct a "unified field theory" in the social sciences and humanities and impose it on everyone. There may be several patterns, and they may *not* fit together. The important thing is to recognize interrelationships and to establish structures which will correlate concepts in a significant way.

On this question one more point needs to be made. In looking for significant structure, the teacher should be alive to the value of general ideas, both old ones and new ones, which relate one set of concepts to another—ideas as general even as the principle of evolution, the problem of unity and diversity, the concept of feedback, and even a generalized version of the law of increasing entropy like that which is being used in this paper.

So far we have been talking about conservation measures, devices for resisting the erosion of knowledge. Such measures are important, but they are not enough. The only systems which make successful, if temporary, stands against the increase of entropy are living systems.

Sound organization is important, but if the system is to survive it must take in nourishment. It must be able to convert the substance of its environment into its own substance. It must continue to operate and function, or it will die. It must even have something which might be called a "will to survive."

The same is true of education. The real reason why specialized education remains intact in the mind of the specialist is that it is kept alive in use. Furthermore, if the specialist is worth his salt, he not only uses his specialized knowledge, he adds to it. The reason much general education does not survive is that it is *not* used. It is not alive. It does not grow. If it survives it does so in a mummified state.

This, I am afraid, is a rather damaging indictment. If the general education which is given the individual is itself viable, it *should* grow, because the conditions of growth are present. This is not a case of good seed on barren ground. Human beings, whatever their specialties, undergo certain general experiences, face certain general problems. These experiences, these problems, are the stuff out of which an education is built.

In theory, the eductaion a man has

acquired should be alive enough to turn these experiences into its own substance, just as the living organism turns the stuff of its environment into its substance. Stated more prosaically, a man's general education should help him to see his general problems more clearly—perhaps even to solve some of them—and the problems themselves should become part of his education.

To make general education into this kind of living thing is our principal job. The suggestions that have already been made are still pertinent. If general education is truly general, it *will* be relevant to the general problems and experiences of life—by definition. It will be potentially living, not dead. It will be useful in the broadest sense. If it has significant structure, it will be equipped to digest and assimilate new experiences and new problems.

But these measures are not enough. The student must also be equipped to use his general knowledge in new situations, and he must be enabled, persuaded, and encouraged to expand it continually, and keep it alive in use.

A former colleague of mine tells a story about a literature course he once taught. A number of years later he visited the home of one of his former students, who pointed to a small shelf of books and said with obvious pride: "There they are, the authors we used in your course."

There weren't any other authors on the shelf. There weren't any additional books by the same authors. "The course," my former colleague says, "was a failure as far that student was concerned."

The incident illustrates the problem which the general studies teacher faces. His job is to create in his students a body of knowledge and experience which in turn will itself be creative. He is not producing something which can be filed away in a notebook or stood on a shelf.

Here again the time limitations under which we work in engineering schools, underscore this emphasis on the future. One term of literature, one term of history, one term of economics, one term of psychology, one term of philosophy—or four or five terms of the lot of them stirred together and reorganized—are hopelessly inadequate if the matter ends there.

All we can do, in the time available, however we cut and splice the curriculum, is to introduce. We have suceeded only if the introduction leads to a more lasting acquaintanceship.

If we accept this role of introducer, however, we will probably find ourselves changing at least the emphasis, if not the content, of many of our courses. We can in fact describe four major ways in which our objectives or our emphasis will be shifted.

First, if we are thinking about creating an education which will resist erosion and even grow and develop, we should set our goals well beyond the final examination. The objective is future use (whatever that means for the subject-matter of a particular course), not the reproduction by our students of our own ideas some morning in January or June.

The final examination may provide some information as to the probable success or failure of the course. It may even motivate the student (though we should be suspicious, in education, of false motivations). Ideally, however, the examination should be a means of organizing the content of the course, confronting the student with new problems which require the total background of the course for their solution. In other words, the examination should itself be a base for future operations.

Second, if we are concerned with the future development of the student in the humanities and social sciences, we should try progressively to free him from dependence on us and our superior knowledge. This is a hard thing for most of us to do. The sound of our own voices in the classroom is, after all, one of the major rewards of our profession.

The difficulty with yielding to this minor vanity is that we may appear to know so many things, and to know them in so complicated a way, that the student comes to mistrust his fledgling efforts to think for himself. How can be understand a poem, for example, when the instructor has repeatedly demonstrated the erudition required for the explication of texts?

If we expect to encourage the student to continue developing his own general education, we must resist the temptation to play high priests of esoteric mysteries.

Third, and this is the corollary of the point just made, we should try to give the student experience *in* the discipline, not merely knowledge *about* it. To be sure, there are facts, concepts, and methods which have to be learned, but there is still time in most courses so that the student can experience the thinking involved, the actual procedures used in the discipline itself.

He should face the problem of the historian in evaluating historical evidence and interpreting source materials. He should, like the social scientist, get a first-hand view of a real community or a real society. He should react to literature and art personally and directly, and he should criticize it for himself instead of relying merely on the critical judgments of others.

He should learn to read philosophers and even to think for himself philosophically, not merely learn about what other men have thought. Here of course there is a major danger. In encouraging students to work in the field, the instructor should not lose sight of the *general* character of the course. He should not try to turn out specialists, but rather laymen who know how to apply some of the specialists' techniques to general problems, and who also know when to turn to specialists for assistance.

Fourth, in all our efforts, we should take care that the student gets some taste of success. This does not mean that he should never be allowed to fail, or that we should lower our academic standards. (Failure can be a powerful motivator, much more powerful probably than *easy* success.)

It does mean that we should try to set up some situations in which the student will be encouraged by his ability to do something he had thought beyond his grasp. The class discussion in which the group collectively comes up with insights which go beyond the insight of the instructor—and this isn't hard to manage—can be very reassuring and stimulating to the able student.

We might even take note of the brainstorming sessions now being used in industry and encourage, on occasion, the free expression of ideas without indulging our own critical faculties too ostentatiously. And even in dealing with the poorer student, we can make sure that the comments we write on papers are not *always* negative, *always* an underscoring of failure.

We need to recognize that our responsibility toward the student is different from the responsibility of the technical instructor. It is his business to discourage the student who is not suited for engineering or science. It is our business *not* to discourage the student from being a member of society, a citizen, and a human being.

In the view which has just been expressed, knowledge is a kind of energy, but it is not a kind of energy which can be stored in some inert form for future use. A body of knowledge is more like a living organism than a coiled spring or the contents of a storage tank.

If it is to be preserved, if it is to flourish and grow, it must be used, and it must be fed by new experience, new knowledge. This point of view is in accord, I think, with the report on *General Education in Engineering.*

In the first chapter of that report, which deals with objectives, there are warnings against three dangers:

1. The danger of defining the functions of the humanities and social sciences too narrowly.
2. The danger of defining their functions too superficially.
3. The danger of defining their functions too ambitiously.

These are warnings. They are essentially negative statements. What has just been presented is a *positive statement* of the same general principles. If we are to overcome the tendency of education to become lost or disrupted, we must certainly avoid narrowness and superficiality, since unworthy formulations of objectives neither motivate the student in the present nor encourage him in the future.

We must also recognize the limitations under which we work, and instead of claiming to do everything, concentrate on the possible—and essential—throwing our major emphasis on preparation for future use. The measure of our success finally is the activity, the thought habits, the interests and sympathies of our students, ten years or twenty years after they have passed—or flunked—their last formal examination in the humanities and social sciences.

TRANSACTIONS OF THE CHEMICAL ENGINEERING DIVISION

Chemical Engineering Education, the transactions of the Chemical Engineering Division of ASEE for 1956–1957, were published recently at Pratt Institute, Brooklyn 5, New York. Edited by Albert H. Cooper, the transactions will be published annually at a subscription price of $1.00 per year.

CONTENTS

1956–1957

A Professional Program for Advanced Study in Engineering, by Donald L. Katz.
The Role of Nuclear Courses in Engineering Curricula, by V. L. Parsegian.
The International School of Nuclear Science and Engineering, by Rollin G. Taecker.
Bio-Engineering at the University of Wisconsin, by E. N. Lightfoot.
Atomization, by W. E. Ranz.
Analog Computers, by Warren C. Stoker.
On the Formulation and Solution of Diffusion Problems, by R. B. Bird.

WHAT CAN YOU TELL A YOUNG ENGINEER ABOUT ETHICS?

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When the subject of engineering ethics was mentioned to a certain engineering student he replied, "I expect to be a practical man, not a philosopher. As I face decisions in engineering practice, the question in my mind will be—'What is the best thing to do?' Right and wrong will be relative factors in each particular case."

It is true that engineers must be practical because they are expected to produce results—results that not only work, but work to someone's profit. It is also true, however, that engineers work not only with things but with people. They work with things that will be an intimate part of the lives of people. No engineer then can ignore ethics except to the detriment of his work, for ethics is the body of principles concerning right and wrong in human behavior, the theory of moral conduct (1). And if this is true, ethics certainly becomes a very practical matter insofar as engineers and their work are concerned.

The practical aspects of ethics are themselves sufficiently important and numerous to present a strong case. One's behavior definitely affects his success as an individual working among men. However, it is questionable that ethics, involving ideals, can be treated only as a coldly practical matter. Today's ideals influence tomorrow's practices. Today's ethical practices determine the nature of tomorrow's society—the society in which our children and their children will live. Therefore, every citizen, as a citizen and a parent, bears the obligation of establishing a sound philosophy of right and wrong and of putting this philosophy to work in his daily life.

What Do We Mean by Ethics?

The foundation stones of ethics may be labeled—

1. Integrity
2. Trust
3. Consideration
4. Loyalty

Integrity implies honesty, fairness, justice, impartiality, carefulness and thoroughness. In its deepest sense it demands humility—humility arising from an honest evaluation of one's accomplishments in the light of his responsibilities and opportunities. Integrity is the basis of *faith* and *trust* which involve dependability, honor and confidence. *Consideration* involves tact, kindness and courtesy and, like sincerity, is a basic requisite of all successful human relations. The common ingredient of all of these foundation stones of ethics—or perhaps the bond that gives them coherence—is *loyalty*. Loyalty cannot exist without integrity or faith and is meaningless when expressed by insincere or inconsiderate persons.

If this is the construction of ethics, are we dealing with relative or absolute values? Can one be 70% honest? Is the threshold of integrity defined by "what you can get away with," or perhaps by "what you can get away with when no one is looking"? Although the answers to these questions may seem clear to the idealist, the

practical person knows that each of us has his own standard of ethics and that this standard depends upon one's social environment, his experiences, his conscience and his religion, as well as the ramifications of the particular situation at hand (2).

The young engineer must set his own datum plane of ethics consistent with his personal convictions but also consistent with the mores of his social setting. At any rate he cannot avoid taking a stand and making a choice when faced with the question, "What do I do now?"

As a professional person he is further bound by the obligations of trust which are placed upon him by society. As long as he must take a stand he should, early in his career, establish a sound basis for his position. If he does not form his criteria before he takes his stand, he will soon find that he has no standards and will have to act on expediency. This, in turn, will lead him into increasingly greater difficulties.

Why Be Ethical?

1. Ethical behavior is a wholesome habit—a way of life that is satisfying.
2. It is wiser to be ethical.
3. Ethical behavior is essential to democracy and free enterprise.
4. Ethics are basic to any profession.
5. Ethics are personally rewarding.

Ethical behavior becomes a wholesome habit—a way of life. Habits are self-perpetuating and self-energizing. Each unethical act makes the next one easier to do. Each ethical acts makes the next one more natural. Thus, the unethical person finds his progress toward moral destruction accelerated, while the ethical man finds his moral strength gaining continuously. Subconscious and spontaneous reactions tend to be sound and wholesome if habits of ethical behavior are established.

In other words, if we live right we'll probably do the right thing automatically. Only he who is honest in discharging his *minor* obligations can be depended on to do the *big job* well, for habit is a cable composed of many fine figurative fibers controlling our actions.

Dishonesty, disloyalty, and untrustworthiness corrupt the personality. They undermine one's self-esteem for, like cowardice, they are cause for shame. Honesty, loyalty, faith, and consideration of others bring self-satisfaction and build strength of character.

When one is dishonest or insincere some persons seem to be able to detect such traits in the guilty person, through some peculiar sense, by his mannerisms and expression. This means that one's habits mark him in subtle ways which he cannot conceal from everyone. Thus, unethical practices injure the doer whether he is caught in the act or not.

It is wiser to be ethical. The person who always does the right thing never has to "cover up" or prepare alibis. He has peace of mind since he has nothing to conceal and doesn't have to "remember what he said." Naturally, no one can do the right thing all of the time, nor can he often afford to postpone action until he deliberates fully as to what is right and what is wrong. If he is in the habit of doing what he conscientiously believes is right, however, he will always be on the side of wisdom.

Individual ethics are essential to democracy and free enterprise. Our western civilization and economy are based upon mutual trust. It is not necessary to have each bottle of milk tested for bacteria content before drinking the contents. As an airplane passenger you do not feel obliged to

inspect the plane before embarking. You trust each person in every organization with which you deal to discharge his responsibilities honestly and scrupulously. If you do not discharge your own individual responsibilities honestly, you are out of harmony with our system—you are a moral outlaw, in effect.

Misbehavior leads to new laws and controls. As laws increase in complexity, numbers, and scope, each citizen is allowed fewer choices. The ultimate result of such a trend is dictatorship or tyranny. Each person is, therefore, a guardian of free enterprise in that his personal actions, however insignificant, contribute either to the building of the way of life which guarantees individual freedom of choice or to the building of totalitarianism (3). Each person must base his decisions on a consistently sound inner law, his conscience. "The law must be in each man's soul"; otherwise, it will have to be written in the law books of the land.

Ethical principles are basic to any profession. ". . . the professional man," according to Dr. E. A. Walker, President of the Pennsylvania State University, "is one whose reputation for competence and integrity is such that uninformed laymen can—and do—entrust their lives, their health, and their property to him. To win his reputation he must first of all approach his calling as a position of public trust (4)." No group, professional or otherwise, can maintain high ethical standards if its members are individually unethical.

An individual cannot long conceal his personal dishonesty or breach of honor within the protective walls of his group any more than one rotten egg can avoid detection in an omelet. Violation of trust destroys the professionalism of an individual and undermines the status of his whole group. One of the basic ethical concepts of professionalism, according to the Engineers Joint Council, is "the acceptance of individual responsibility." Professionalism implies not only professional competence but professional morality.

Ethical conduct is personally rewarding. Loyalty begets loyalty. Tact, consideration, kindness, and courtesy get results. Honesty engenders trust and respect. If your work depends on the loyalty of others, on getting results through the efforts of others, and on the trust and respect of others, ethical behavior on your part will be well worth while. Indeed, if you violate the fundamentals of ethics you cannot expect to go far in your work unless you thrive in an atmosphere of distrust and animosity.

Today's ethical behavior makes tomorrow a better day. Either the world will become a better place in which to live and raise our children, or it will become a poorer and unhappier place. The very essence of ethics is harmony, cooperation, and mutual trust. Therefore, any and every small contribution to raising the "center of gravity" of the nation's moral standards through our individual acts rewards us through the betterment of the system in which each of us must live.

A clear conscience is a great asset to any man because it leaves more room in the mind for creative thought; it gives one a feeling of self-respect and confidence which enables him to face his tasks with strength and confidence. It takes a strong man to do what he feels is right. The mind which is busy concealing things seldom is aware of opportunity when it knocks.

Basic Ethical Principles

Volumes have been written on the fundamentals of ethics and, no doubt,

more volumes are yet to be published. For the young engineer who seeks a working philosophy, however, a few salient principles can be listed as follows:

The principle of the Golden Rule. Treat the other fellow as you would like to be treated if you were in his place. This is a profound law which requires the utmost in objectivity and empathy, the ability to project one's self into the other person's situation with a full awareness of his point of view.

The principle of mutual trust. "He will do right by me"; "A promise is made to be kept"; "Don't let the team down for personal gain." The American way of life cannot survive if this principle dies. This may be called the principle of doing the right thing when no one is looking.

Some measure another's level of ethics by what he tries to get away with when he knows no one is looking. As Polonius stated it, "To thine own self be true. Then it follows as the night the day, thou canst not then be false to any man." Titus (3) says that "Taking all that one can grab without punishment is a reversion to barbarism."

The principle of public trusteeship. The true professional engineer desires to contribute to civilization rather than simply to benefit from it. He accepts responsibility as an individual to protect the health, welfare, and safety of the public; he places this above his own personal gain.

"Whatsoever a man thinketh, so is he." Emerson stated this principle as, "What you are speaks so loud that I cannot hear what you say."

Ethical Relations

Be ready to help the other fellow. Remember, however, that people are uncomfortable in the presence of their creditors. Cooperate but do not impose.

When you have a complaint, go to the individual responsible for the function involved. Give him a chance to correct the situation and thereby to save his face. Tell him the truth when it is for his good—even though you may find this hard to do at times.

Give credit where it is due. Boost the other fellow in the eyes of his associates, superiors, and subordinates; but do not exaggerate. Lavish praise may raise questions as to your sincerity and motives, thus injuring rather than helping associates.

Don't "muscle in." At certain times circumstances are such that, in order to get a difficult assignment done as required of you, you will find yourself obliged to risk "stepping on someone else's toes." As in the case of all risks, the consequences must be weighed carefully and action taken according to one's best judgment. A reputation for integrity and consideration goes a long way at times like this in maintaining wholesome personal relations. As a general rule, it is most hazardous to violate either of the following principles:

a. Stay in your own territory.

b. Always work through the designated organizational channels if your assigments involve areas outside your own.

Never propagate rumor (5). Rumors are insidious things. In some organizations they become a malignant growth which impedes and often destroys the organized channels of communication. They confuse the earnest person and delight the troublemaker. One does not have to repeat a rumor to be labeled a gossip; mere listening may accomplish the same thing.

Do not trade restricted information

with associates, for in so doing you not only violate the trust which has been placed in you but sacrifice your associates' respect.

Compete cooperatively. Work together to get the company's work done. Compete for your own personal advancement. "Keep your eyes on the common goal, not on each other" (9). This requires character of a high type. Sections 19 through 28 of the *Canons of Ethics for Engineers* (6) present a sound guide to successful association with fellow engineers.

With One's Superiors

"Never overlook the fact that you are working for your boss. Work through him" (7). Help him, inform him, and support him at all times. You assumed the obligation to do this when you agreed to work for him. Furthermore, you assumed the obligation to perform to the best of your ability, to contribute your best workmanship, your maximum creativity, and your most diligent effort.

Your superiors depend on your competence, loyalty, and integrity as you depend on that of your subordinates (8). All of your work cannot be checked in detail. Carelessness is a breach of trust. Your superiors have a right to expect you to be loyal yourself and to promote loyalty and morale among your associates. They have a right to expect you to protect the company's interests.

Stealing from the company is an act of dishonesty in any of its forms. Padding the expense account, pilfering supplies, and using company equipment and time for personal projects are obvious forms of stealing which can mark a man for failure. On the other hand, subtle forms of theft are even more serious in their consequences.

Don't give away company data, or use them for personal gain; don't "wash company linen" in public; don't capitalize on your employer's name; don't accept compensation for outside work or otherwise detract from your performance on the job without your employer's approval; don't accept commissions for purchases which you have recommended.

Your time, your effort, and your genius belong to your employer under most employment agreements, whether written or tacit. Work hard and cheerfully. Try to enjoy your work and give full measure to the job. You have to do more than you are paid for to get what you are worth.

Be honest with yourself and your employer and don't blame low wages, long hours, or weak supervision when your unsatisfactory performance may be the result of your own failure to apply yourself, lack of interest, carelessness on the job, or outside troubles (9).

"Loyalty is an ethical imperative" (5). Allegiance to constituted authority is a fundamental requirement for successful performance. No organization can succeed unless strong threads of loyalty run throughout the fabric of its personnel, for loyalty alone will yield trust and service when all else fails. Weak loyalty causes as many business failures as poor planning or faulty management. Do not remain with any organization to which you cannot be loyal, or you will ultimately contribute to its downfall and your own.

With One's Subordinates

Every supervisor is responsible for the actions of those over whom he has supervision. He accepts his position on this basic condition. Any failure on the part of his staff to perform satisfactorily on the job is his responsibil-

ity and he cannot ethically "pass the buck." Presumably, such failures indicate a failure on his part to maintain adequate working conditions in his department.

Be honest in making assignments. He will not expect the impossible from any subordinate. Neither will he underestimate an individual's capacity and put him in the position of having to apologize for carrying a light load. He will be as fair and kind as possible, recognizing that he owes consideration to those who help to get his organization's work done. He will provide adequate training and the best possible working conditions and supporting staff. He will take time for creative thought on his own part to be a source of inspiration at all times to his people.

Give credit to subordinates when they deserve it. Don't be afraid to "stretch a point" occasionally. Never, by contrast, tell a worker that he is doing well when this is not true, nor criticize anyone in the presence of others, however deserving of criticism the offender may be. The wise supervisor will not prevent an efficient and deserving subordinate from finding a better opportunity outside the department; it is the leader's responsibility to encourage every one of his staff to reach a maximum level of attainment.

Try to understand individuals. The wise leader will try to bring out the best in each person. He will aim to accomplish things through cooperation rather than the assertion of authority. He will ask, not order; he will inquire, not declare; he will listen, not talk.

In this way he will be leading rather than driving, encouraging thoughtful response rather than servile reaction, building self-confidence rather than stifling initiative. Understanding his people, he will know when to command and when to request in order to get the results required of his group.

The supervisor's chief goal is to develop his department to its maximum possible level of productive efficiency. He owes this not only to his superiors but to his subordinates as well. The latter look to him for leadership in establishing a record of which they can be proud. In other words, they deserve the best possible boss. As their supervisor, in all fairness, this is what you must give them.

With Clients, Customers, Vendors, and the Public

You cannot accept favors without expecting to "pay off." Gratuities, bribes, unearned commissions, and kickbacks not only exert unfair pressure on the donors but build up a debt of obligation on the side of the recipient which can be discharged only by repayment to the satisfaction of the donor. The settlement of such accounts invariably violates sound business practice and leads to serious trouble for those involved. The significant point here is that all such trouble has its inception in the acceptance of a small, often seemingly inconseqential, gift or favor (10).

Misrepresentation of one's product or service is unethical even when it consists only of a slight, undetectable shading of test results. The engineer who alters his laboratory's readings in the direction of his client's expectations or hopes bears as much guilt as the production manager who furnishes his customer with "production samples" which were really hand-made in the tool room.

An article may be misrepresented indirectly by maligning that of a competitor and thus drawing unfavorable comparison. The engineer deals with facts. He soon learns, however, that just as figures may be made to lie,

facts can be made to mislead. No true member of the engineering profession will yield to the temptation of so misusing one of his most powerful tools.

An act of omission can be as unethical as an overt act of dishonesty. Enginers often gain possession of information which is of importance to the public as well as to their employers. While their primary loyalty is to their employers, their professional obligation is to the public.

The engineer who participates in withholding information which is essential to the welfare and safety of the people seriously violates his trusteeship. An employer who expects his employees to engage in this practice is not worthy of loyalty from any quarter. The engineer likewise must exert special effort to protect the public from any ill effects that may arise from the activities of his company or the use of its products. Here again, negligence or failure to act on his part definitely breaches the public trust which he enjoys as a professional man.

Deal only with ethical parties. This rule is not only the safe one to follow; it has a deeper significance. To deal with unscrupulous organizations is to support them and encourage them to extend their unethical practices. The ultimate result of such encouragement would be the destruction of our successful system of mutual trust. Every engineer has the responsibility of sacrificing any immediate benefits of such dealings for the total good of our way of life.

In Summary

"Courage and integrity are prime requisites for a successful engineer. Do not continue in engineering if you are afraid to take calculated risks and to make decisions on the basis of available information, for very seldom will you be able to figure out a dead-sure answer in advance for any major engineering problem. Don't go in for engineering if you are satisfied just to 'get by'; shoddy work will not do where human lives and heavy investments are at stake. Engineers deal with the laws of nature. These laws are fixed and inescapable. The engineering practitioner, therefore, must be rigorously honest in thought and in action; no amount of brilliance will enable an individual dealing with such matters to ignore or to attempt to distort even the simplest laws of nature. Don't go in for engineering unless you are willing to live up to an inflexible code of integrity and honest dealing; the habit of straight thinking and honest action is just as important to an engineer as is the habit of cleanliness to a surgeon. The laws of man may be propounded, enacted, enforced and changed in accordance with the whims or expediency of the human mind. The laws of nature, however, require forthrightness and steadfastness if disaster is to be averted or the wastage of money and materials avoided. Engineering has no place for men who are merely smooth or clever. Clever argument and disputation may not be substituted for the integrity which an engineer must possess" (11).

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COLLEGE NOTES . . .

Richard G. Folsom succeeded Livingston M. Houston as President of Rensselaer Polytechnic Institute on March 1. Dr. Folsom formerly directed the University of Michigan's Engineering Research Institute.

Dr. Ernst Weber was elected by unanimous vote of the governing body to succeed Dr. Harry S. Rogers as sixth president of the Polytechnic Institute of Brooklyn. Dr. Weber formerly served as vice president for research in charge of Polytechnic's scientific and engineering research programs. A member of ASEE since 1935, Dr. Weber is Chairman of the Evaluation Follow-up Committee and served on the General Council during 1952 through 1954.

Robert L. Sumwalt, dean of the University of South Carolina School of Engineering, became acting president of the University on December 1, 1957. He succeeded Donald Russel. Dr. Sumwalt has been a member of the South Carolina engineering faculty since 1926.

Alfred J. Ferretti, head of the department of mechanical engineering at Northeastern University, was recently granted the rank of Fellow of the American Society of Mechanical Engineers. The transfer from Member to Fellow is an honor reserved for less than 400 of the ASME's 50,000 members.

Joseph A. Boyd has been appointed associate director of the Engineering Research Institute at the University of Michigan. He has been granted leave from his duties as associate professor of electrical engineering for the duration of the ERI appointment. Professor Boyd succeeds Professor Merrill M. Flood, who will now continue as professor of industrial engineering.

Professor Donald L. Katz, Chairman of the department of Chemical and Metallurgical Engineering at the University of Michigan, has been named Vice President of the American Institute of Chemical Engineers for 1958. The announcement was made at the annual meeting of 16,000-member Institute.

A PLAN FOR INTEGRATING COURSES

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It has long been the goal of educators to knit together a series of courses to form an integrated plan of education. Unfortunately, the author is not aware of any school in which true integration is really practiced. Rather, most schools rely upon an orderly sequence of courses to fulfill the purposes of a curriculum. Though the problem is old, a perfect solution has not yet been evolved. But a step in the direction of integration can be readily accomplished without upsetting the courses, the procedures, or the faculty in their present work.

The plan will be described in more detail but it can be summarized as follows:

1) In the freshman year a scale model of an industrial enterprise will be shown to the students and discussed by the Dean, by various professors, and by experts from the industrial world.

2) Inspection trips will be arranged to the full-scale plant in question, thus correcting designs, drawings, and full-scale practice.

3) The details of design, construction, and production, research, and marketing relating to the model plant will thereafter be referred to and discussed throughout the four years of education in almost every course that the student undertakes.

Interest

What is the most important single item necessary for the learning process? Though you may not agree with the distinguished educator Alfred North Whitehead on every point, we would probably be united in our answer that *interest* is the prime requisite to continued learning. The hickory switch can influence the learning process temporarily, but the most desirable and usually the most significant outgrowths of learning have resulted from motivation on the part of the student—*the desire to know*, not the fear of dullness or stupidity. The technical ability and interest of the modern educator are rarely missing but, too frequently, interest and imagination are not transmitted to the student. Even the most dynamic instructor periodically "loses his touch" and needs a supplement or stimulant to recapture the attention and restore the direction of his class.

Integration of Ideas

Consider an integrating plan which will not only lend significance to some of the many problems that the student is asked to solve but will also indicate the role of a particular course in the whole of engineering. The plan could begin by bringing together for a day all of the freshman engineering students and introducing them to a model industrial plant. As an example, this might be an aluminum plant with all of its associated buildings and facilities, including power house, office structures, settling sheds, transformer stations, and similar facilities, or any other industrial installation of some complexity.

The Dean of the school could well begin the day's program by indicating the impossibility of learning everything about engineering in the few years that are spent in college, emphasizing at the same time that most of the fundamental principles which provide the basis for engineering solutions will be made clear and exem-

plified for the student. The Dean would then introduce selected faculty members and also a high-ranking representative of one of the aluminum companies. These men could give brief talks on the general operation or salient features of the model.

Applications

Once the student has been introduced to the nomenclature involved in the aluminum field, the whole attitude of the meeting would change from one of generalities to a systematic, though brief, look at the many major components involved in the plant. A logical place to begin would be at the power plant, from which an almost unbelievable quantity of electrical power is generated. Following an introduction to a cutaway model of a modern multi-storied boiler, a ten or fifteen minute motion picture could be shown to illustrate the magnitude of such a structure, perhaps in various stages of construction.

A thermodynamicist could indicate specific details concerning combustion and use some homely model to demonstrate incomplete combustion—possibly a burning candle. A metallurgist could point out materials suitable for high temperatures. He would differentiate between brittle and ductile materials, and demonstrate these properties through the behavior of glass and rubber.

The metallurgist could be followed by a structural engineer who would add a bit to the discussion and point out the problems involved in supporting the boiler and designing for the large structural growths arising from the change in temperatures. He might lead the students into a particular part of the plant with his problems and descriptions and then turn the meeting over to an electrical engineer.

The electrical engineer could well outline the highlights and problems involved in the production of electricity and the control of generators. He would lead the tour away from the alternators to follow some of the power cables and discuss aspects of power loss, insulators, transformers, and then quite logically turn the program over to a chemical engineer. The problem of utilizing the electrical power in aluminum production involves chemistry and the engineering applications of chemistry. One or two questions concerning filtration and concentration in terms both of physical and economic considerations could be considered by the chemical engineer.

In this way the student would be exposed to some of the actual problems encountered in the various branches of engineering. The model-scale program, in conjunction with a more informal chat with one or two engineers, could help the student select the path in engineering that seemed most interesting.

But of course a one-day session should not be the end of the demonstration. Every engineering course taken in the school should periodically refer to the model. Probably the first "engineering course" would be one in drawing or descriptive geometry. Sometime during these courses the student would be asked to make a detail drawing of a header, or a perspective drawing of the pump house, or to analyze the angles and lengths of a particular superheater tube. At the discretion of the instructor students would perhaps make several trips to the "model room" in order to solve these and other related problems.

Further Uses

As an indication of the ways in which this program could be carried into the various branches or departments, consider the student majoring in mechanical engineering. He would

find himself facing the model time and time again to make a heat balance of the whole plant (Heat-Power I), to work out a better crane support (Machine Design), to solve a problem dealing with the heat transfer characteristics of the boiler or condenser (Heat-Transfer II), or to compute the natural fundamental vibration frequency of the turbine rotor (Dynamics of Machinery).

The model and the blueprints of the associated equipment would serve as a beginning point for improved designs, would offer some touch with reality in terms of size and physical layouts, as well as provide sample problems of a reasonably elementary nature. But the fact that the student returns to the model which serves jointly, say, the Mechanical, Electrical, Chemical, and Civil Engineering curricula, would minimize his impression that the various branches are separate entities in themselves. In addition, his fellow-students in the various other engineering majors would be back in the model room intermittently to gather pertinent data necessary for the solution of their problems.

Little stretch of the imagination is required to see the possibilities for including courses from the College of Liberal Arts in this integrating plan. Economics, Statistics, and Business Planning would take on considerable importance when related to the model room. And even the much-neglected course in English Composition would receive a new spark of interest if a paper or two were concerned with the model industrial enterprise.

The use of the model by the instructor would accomplish a two-fold purpose. It would provide a spur of interest to help counteract the mid-term slump (or any other interest lull) and hence would benefit both student and instructor. Of even greater importance, the model would provide the drawstring for pulling together many seemingly unrelated courses. No longer would Heat Transfer II or Elementary Structures remind the student of some sketchy ink-blotted notes filed in the bottom of some drawer ("I'm not sure which one, . . .") but would instead remind him of one consideration of importance to every large engineering project.

No longer would he be concerned with "just getting through" a course; instead, it might contain a choice bit of information that would permit him to solve some specific type of problem for the model plant. Nearer the completion of his college career, he would grasp the overall picture of a major design because he would be familiar with at least one very complicated layout. He would have developed his thinking process into different methods of analysis, so that he would not be afraid and mentally befuddled when facing a project of considerable magnitude.

Immediate Value

This paper claims no panacea for the great philosophical problems related to engineering education. The ideas presented are to be considered as a supplement, an aid in the integration of courses *now* being taught. The degree of integration would still be determined by the individual instructor and the applicability to his own courses.

This plan does, however, have the virtue that it can be called into action *now*. It can stimulate students *this* year, rather than waiting forever for the perfect solution (if there is one). The approach suggested, then, can convert into an integrated curriculum individual courses that are now being presented. Or, perhaps more important, this program can stimulate further discussion that will lead to a still better plan.

THE REJUVENATION OF A MATERIALS TESTING LABORATORY

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It is nearing the end of the term. Preliminaries are out of the way and projects have been approved. The laboratory takes on a preoccupied look every afternoon as one class after another meets to carry out its various investigations. During this particular two-hour period one party is discovering that glass surface-etched with hydrofluoric acid is stronger than before, and is studying the effects of other treatments such as sodium hydroxide and diamond scratches.

Another group is getting a first hand look at the peculiar behavior of polyethylene and nylon in simple tension, and is plotting stress-strain diagrams for these materials. Still another team is studying the variation in mechanical properties of plain carbon steels with changes in carbon content. The fourth is determining the variation in resistivity caused by mechanical strain in certain metals.

Nobody seems to be loafing on the job. After all, these are individual problems, chosen by the students themselves. Why shouldn't the class be interested? Many of the experimenters have spent hours making advance preparations for today's experiments. Reference books have been used extensively. Special materials have been sought out and special apparatus has been borrowed. Definite plans have been made for the conduct of the investigation and for the items of information to be determined.

After today's work is done and calculations are complete, each student will write a brief formal report on the conduct of the tests and the results obtained. Some instructions on the proper form of an engineering report have been given, but the students understand that they have great leeway in just how their own individual reports are to be written. When the accounts come in, a week later, they will represent a wide variety in length, content, and style. But they will nearly all be good. For one accustomed to the usual routine materials testing reports they are positively amazing!

Traditionally Dull

Materials Testing Laboratory has traditionally been a course that fails to arouse the interest—much less the enthusiasm—of the average student. Consisting mainly of a set of routine experiments, it lacks the appeal either of the analytical course where new principles are learned and used, or of the professional course where the practice of engineering is followed.

Being a laboratory course, there are usually no lectures in which an adequate theory can be discussed, unless the brief preliminary instructions can be classed as lectures. The experiments are carefully laid out for each week, possibly using a laboratory manual written by a local professor, perhaps only a syllabus.

As far as the students are concerned it is the "busting lab." Each week they come and listen half-heartedly to the instructions which they avoid reading themselves if at all possible. They conduct the planned experiment, record pages of data, break the specimen, make more pages of com-

putations, draw a few graphs, and then what?

Well, there is a report to write. Data sheets and graphs make good filler, but what about the "conclusions"? This same test has been run in an identical manner for several years or decades; it has become in effect a "canned" experiment. The "conclusions" last year's students used are to be found in last year's reports. What more can be added? Nothing! So, the report is written, re-traced, if you prefer.

In spite of these shortcomings, there have been good reasons for the inclusion of a Materials Testing Laboratory course in most engineering curricula. Some of the original reasons are no longer important in the light of present developments in engineering. The importance of any course must always be weighed against that of other more pressing demands on the time of the student. Nevertheless, the Materials Testing Laboratory can fulfill a number of necessary functions in the field of materials and has been retained in some form by most engineering colleges.

At Stanford, for example, the study of engineering materials has for some years been divided between three courses: Metallurgy, Mechanics of Materials Laboratory, and Concrete Laboratory. It is with the second of these courses that this discussion deals. Until recently it has been a more or less typical materials testing laboratory sequence for the Mechanics of Materials course. Though separate for administrative reasons, one of the main laboratory purposes was experimental verification of the theories developed in the lecture course.

A second purpose was that of teaching the methods of studying materials by means of standard tests. With this came considerable training in the operation of testing equipment and in report writing. There was also some opportunity to study the properties of a few materials through nine tests made in the laboratory, with an equal number of reports.

As in many other engineering schools, there was a growing dissatisfaction with the treatment of the science of materials under this system. The metallurgy course was concerned almost exclusively with metallic materials, and the materials laboratory was so tied up in verification that next to nothing was being given on several vital aspects of the general subject of materials.

In order to improve the state of affairs it was decided to de-emphasize the laboratory aspects. With the time thus gained it was felt that a general treatment of materials could be inaugurated that would give students a better overall picture of the subject and its applications to specific types of materials used in engineering design.

The de-emphasis of the laboratory work would have certain inherent benefits. Much of the time students had previously wasted on repetitious calculations would be saved. Training in operation of machines could be reduced to the minimum. At the same time it was necessary to devise a new method of conducting the laboratory that would fulfill the requirements of the course in a much shorter time.

The first step was to decide on the really necessary functions of the laboratory as required by the new course. One of the first to be dropped was that of verifying elementary theories. Based on simple assumptions like Hookean elasticity, these theories are readily accepted by the student.

Most students tend to look on experiments intended to verify deflection formulas and the like as just so much toy-play. Perhaps this is partly

the result of the observation that in the hands of inexperienced operators the experiments as often as not fail to verify the theories anyway.

It is highly doubtful if any of the usual experiments of this kind succeed in "driving home" any of the theories studied. The new course was therefore no longer considered as a laboratory course for Mechanics of Materials, and its name was accordingly changed to Properties of Materials. The primary purpose of the new course is to establish a basis for an understanding of engineering materials from a general point of view.

With this in mind, a series of lectures has been developed, emphasizing the atomic structure of solid materials and the role of structure in determining mechanical, electrical and magnetic properties. The part played by imperfections in all kinds of materials is brought out, and a number of special properties important to engineers are discussed.

It is the sole purpose of the laboratory to aid the lectures as efficiently as possible. That a laboratory is still a necessity is apparent from the fact that in the range of behavior beyond the simplest elastic conditions, experimental methods are still our most important tool.

Study of the properties of materials has not yet been reduced to an exact science; there are too many uncertainties involved. A properly conducted laboratory can therefore give the students some feel not only for material properties but also for the uncertainties involved, and it would seem a mistake to allow our graduates to leave without having been exposed to these "facts of life." This requires that the student learn a certain minimum about standard methods of testing, not as an end in itself, but as a means of gaining the best possible understanding of materials.

Interest in Learning

It is almost axiomatic that if a student has a direct personal interest in a subject he will learn more than if such an interest is lacking. The laboratory in our new course is built around this principle. The central core is a comprehensive experiment called the "Individual Problem" which is the culmination of all work that precedes it.

Beginning in the fourth week of the term, after the necessary ground-work of theory has been laid in the lectures, a series of three two-hour laboratory periods is devoted to demonstrations of the behavior of materials under the most commonly used mechanical tests. The first period considers simple tension. Two or three different materials are tested using an autographic stress-strain recorder.

The class, which is limited to fifteen men (usually fewer), under the guidance of the instructor observes the conduct of the test closely and the reaction of the material to this type of load. Data recorded by the students include material, diameter, gage length, recorder scales, maximum and breaking loads, final length and diameter, and type of fracture.

At the next laboratory period prints of the recorded curves are distributed. No formal report is required, but homework is assigned in which mechanical properties such as stiffness, resilience, various strengths, and ductility are to be computed from the curves and the recorded data. During the first period the students are also given an opportunity to examine and observe the operation of a number of strain gages, including both mechanical and electrical types.

In the second laboratory period a few of the simplest compression and shear tests are conducted. The majority of these tests are made by the

students themselves in parties of three or four. This provides an opportunity for the students to operate the various universal testing machines in the laboratory under non-critical conditions, with a minimum of training for the conduct of their individual problems.

Several different materials are used, such as concrete, wood, mild steel, and cast iron. Thus opportunities are provided for observation of the behavior of both ductile and brittle materials under compression and shear loadings. Ultimate loads and types of failures are recorded on prepared sheets, corresponding stresses are computed, and the results are handed in as a homework problem. Again no formal report is required.

The third period is devoted to demonstrations of fatigue, hardness, and impact tests. The instructor starts the fatigue machine at the beginning of the period, using a load chosen to insure the likelihood of specimen failure before the end of the period. He then conducts a series of hardness tests designed to illustrate the use of various types of machines and to show the effects of certain important variables.

Finally, he demonstrates the use of the impact machine with specimens of several types of steels. The students record on a prepared sheet the readings obtained in all tests, look up tensile strengths on a hardness table, and record the types of fracture in the impact tests. This sheet is then handed in without other formal report.

It is now time to begin work on the final experiment—the Individual Problem. Preparations have actually been under way ever since the beginning of the course. Because it is intended to be an investigation of some particular aspect of materials, one developed and carried out by individual parties according to their interests, every effort has been made to accept and use special problems proposed by the students themselves. Most students, however, have only vague ideas about what might be done along these lines; consequently, a list of suggested subjects is distributed at the beginning of the term.

Subjects listed are those for which equipment is readily available in the laboratory, though the following are some typical examples:

- Fatigue study of a metal.
- Impact strength vs. temperature.
- Variation of strength of wood with moisture content or density.
- Torsion tests of mild steel or cast iron.
- Stress distribution in WF steel beam, using SR-4 and Whittemore gages.
- True stress-strain test of a ductile metal.
- Tension and compression tests of various common plastics.
- Variation of resistivity with strain.
- Magnetostriction forces.
- Effect of surface treatment on the strength of glass.
- Variation of strength of steel with carbon content.

Other steps taken in preparation for the individual problem include demonstration tests, a lecture on design of experiments, and many individual discussions. It is suggested that such experiments be carried out in parties of two to five students if possible. This means that the students must get together beforehand and explore common interests. This usually is done during the preliminary laboratory periods.

When everyone has decided on the subject he would like to investigate and the people he would like to work with, a prepared slip is turned into the instructor indicating the choices. So that the students will get a chance to

see all the standard experiments before making their choices, the slips are not required until the third laboratory period which is in the 7th week of the course.

When the slips are all in the fun begins. First there is the task of sorting and scheduling experiments. A few students are sometimes left by themselves, but they can usually be added to another group with no difficulty. Specimens and equipment for the listed experiments are all ready, but more of some specimens may be needed because of heavy signups for those subjects.

Also, students who choose special tests of their own design usually need different specimens. It is up to the instructor to try and schedule things so that the machinist will be able to make the specimens required without developing ulcers. Considerable foresight is sometimes necessary to accomplish this.

In the meantime the students are active, too. The great majority in the class tackle their projects with interest and in some cases with enthusiasm. Reference books are used extensively and great effort is put into procuring special materials and equipment. The week following the third laboratory period is devoted to conferences between the research parties and the instructor to help organize the plans and preparations for the experiment.

When the time comes to work, then, everyone is well prepared for the Individual Problem. Each party brings a preliminary outline in which the purposes of the proposed test are discussed, the procedure to be followed is described, and the items to be computed are listed. A hum of activity pervades the laboratory as interesting and informative investigations proceed on all sides.

Some tests, like those for fatigue, require occasional attention over a period of two weeks or more. A party studying the effects of artificial aging by ultraviolet light on the recovery characteristics of various plastic foams began a week ahead of time and was still gathering data just before the end of the term. Saturated wood samples for determining strength as a function of moisture content must be dried for varying lengths of time and then dried again completely following the tests.

The most encouraging thing about all this is that the students are interested enough to put in all the extra effort that is necessary. The few who would prefer just to sit back and go along for the ride do not seem to be very successful. Perhaps they feel the enthusiasm of the party for their project. The whole atmosphere of the laboratory is different.

Instead of the usual atmosphere of resignation, or "let's have some fun with this machine and see how high it will go before the instructor notices and tells us to shut it off," there is a preoccupied atmosphere, as if everyone were too busy to try any such shenanegans. This feeling carries over to the reports, too. In the general instructions for this report it has been made clear that length and uniformity are not the objectives.

The individuality of the experiments and the limited amount of time available for writing them up have been fully recognized. A few specific requirements and suggestions about form and content have been given; beyond that, the students are on their own.

Because this is the only report required in the course, most students seem to rise to the occasion. Few if any of the reports are careless in appearance. Averaging seven or eight pages, they usually include an introduction, data sheets, tabulated results, graphs, and conclusions. The time

spent in writing them averages from four to eight hours, although some may spend a great deal more.

The result is a surprisingly large number of good engineering reports, each representing a substantial amount of thought and learning in one area of the science of materials. And along with learning in one area comes learning in all the related areas that must be used in order to conduct the experiment. In my opinion, this is greatly to be preferred over a mere "going through the motions" in a series of routine tests that try to cover the whole field of materials.

General Assessment

Strongly as I feel that this represents an enormous improvement over the old materials testing laboratory, the impression should not be given that the course will run itself automatically or that difficulties may not be encountered. Such a course, like all attempts at better teaching, requires careful planning. The demands on the time of the professor in charge can become almost overwhelming for a few days just before the Individual Problem. There are moments when he may say to himself that it is not worth it, and feel like dropping the whole thing.

Also, there are the occasional *very* individual projects that just do not work out. But then that changed atmosphere of effort develops in the laboratory, and a few days later the reports begin to come in. It is then that the professor feels that he has really accomplished something. He has sacrificed quantity for quality. He has sacrificed a few days of his time for a real learning situation in the materials laboratory. The results well justify the sacrifice.

STATEMENT OF ABC CONFERENCE ON DRAWING PRACTICE OCTOBER, 1957, TORONTO

Delegates from America, Britain and Canada, meeting in Toronto on October 11, 1957, have examined and considered the respective publications of the three national standards bodies relating to engineering drawing practice, namely American Standards Y14.1-Y14.6, B.S.308, and CSA B78.1. The delegates have propounded recommendations, the implementation of which will eliminate any significant difference in principle so that drawings prepared in accordance with any one of these three standards, when amended, will be capable of being readily understood and used in the factories of each of the countries.

This is the successful culmination of a project which has been patiently pursued for some twelve years. The result will greatly facilitate exchange and mutual understanding of designs and manufacturing data amongst the countries concerned, and eliminate the necessity for preparation of fresh drawings. By providing designers with a common language, the results of this session should lead to lower costs and improved security. In a state of emergency, it will permit the assignment of component manufacture between the three countries to take full advantage of their manufacturing facilities and so achieve maximum production.

Prof. R. P. Hoelscher U. S. A. Lt. Col. A. N. Huddleston Canada Mr. T. R. Houston U. K.

AN ENGINEERING TEACHER LOOKS AT THE HUMANITIES PROGRAM

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This article is based on a talk given before the Humanistic-Social Division, Fall Meeting, ASEE Middle Atlantic Section, New York, Dec. 3, 1955.

The Grinter report [1] on the evaluation of engineering education again focused attention on the humanistic and social studies program desirable in an engineering curriculum. The report stressed the aims of such a program, but paid scant attention to detailed objectives and effective methods of presentation—the aspects primarily responsible for the shortcomings of our present programs.

Not all engineering teachers agree on the value of liberal arts courses; many believe that students must have a natural inclination and a strong interest in fields outside of engineering to gain from humanistic studies. These teachers view the emphasis on liberal arts with alarm, and argue that the limited time available in an undergraduate curriculum can be devoted with better results to a strengthening of technical subjects.

This writer disagrees with these reservations; a strong humanities program should be both possible and feasible, but only after all questions regarding course material, presentation and, especially, student motivation, have been satisfactorily answered. A humanities program should be considered successful if a sizeable portion of the student body is imbued with cultural ideas and an appreciation of values and if this knowledge leads to an avocation in addition to the vocation of engineering.

But liberal arts instructors must be fully cognizant of the challenge posed: The humanities are on probation. The present favorable attitude of engineering administrators towards a strong liberal arts program is probably as strong as it is ever likely to be. Failure to take the initiative may sharply reverse this view and humanities may be eliminated from the engineering curriculum.

Student motivation is undoubtedly the most pressing problem. It can only be provided by humanities courses on a level commensurate with the student's growing maturity in his scientific work. An intellectual bridge to the student's mind is needed to foster knowledge and the growth of humanistic ideas; a large number of thinly spread introductory courses taught indifferently to an antagonistic student body must lead to failure. Motivation, presentation, and selection of course material should, therefore, be the principal concerns in any liberal arts program addressed to engineering students.

A suggested humanities program will be outlined in some detail on the following pages. This will be done with the full realization that an overemphasis on curricula can become a straight jacket rather than a conveyance of ideas; the method was chosen

[1] *J. of Eng. Ed.*, Vol. 46, No. 1, Sept. 1955, pp. 25–60.

solely to formalize opinions. However, before proceeding along these lines, it may be instructive to re-examine the scope of present humanities offerings.

Review of Present Humanities Programs

Based on the latest catalog information available in December 1955, a study was made of all accredited four-year engineering colleges in the New England, New York and New Jersey area, where courses in one or more of the fields of Civil, Electrical or Mechanical Engineering are offered. The schools selected totaled almost one-quarter of all accredited institutions and should, therefore, represent a fair sample. The principal results of this survey are listed below.

An average of six credit hours of Freshman English was required by 24 of the 29 schools; two colleges allowed other courses to be substituted after a substantiating examination had been passed and one college required remedial work without credit if the student's performance in composition and grammar was found to be unsatisfactory.

Most frequently, required humanities courses included: Economics (21), Literature or Scientific Literature (17), History, including American History (11), and Western Civilization (9). Social Studies were compulsory in six schools, Political Science in three.

Nineteen colleges permitted great freedom in their liberal arts electives, but only two required a sequenced selection on any one field; the others allowed students to select any number of unrelated introductory courses.

Three colleges gave humanities credit for Business Administration, one for Labor Relations, and one school even accepted Band Music.

Minimum percentage program requirements in the humanities ranged from 19% to 5.8% for non-R.O.T.C. students (excluding Freshman English, Technical Writing and Speech). The median of all colleges was 12.5%; if Freshman English be added, the median was raised to 16.8%.

Where R.O.T.C. substitutions for liberal arts courses were permitted, minimal requirements dropped sharply. Of the 27 colleges with Advanced R.O.T.C., ten allowed no substitutions, eleven listed specific alternatives up to twelve credit hours, and six schools took great pain to remain unspecific in their bulletins. The suspicion may, therefore, be strong that R.O.T.C. substitution was the rule rather than the exception. The eleven colleges with specific bulletin information listed minimal humanities requirements ranging from 11.5% to a value as low as 2.1% (excepting Freshman English, Technical Writing and Speech).

Discussion and Evaluation of Published Programs

Any evaluation of present programs must reflect the opinions of the writer, who as an engineering teacher may have a perspective different from that of a liberal arts instructor.

One conclusion is immediately apparent: The twenty per cent humanities schedule suggested by the Grinter report was rarely observed, especially when R.O.T.C. substitutions were considered.

Probably more important, if less obvious, is an evaluation of the nature of the humanities programs. Restricting the discussion for the moment to universities with liberal arts colleges, what can be less effective than a long string of unrelated humanities courses, all offered on the lower class level? Every sequenced package course in "Advanced General Studies" offered by the Service Humanities Department of an "Institute of Technology"

is likely to be superior in content and motivation in spite of its inherent faults. The tremendous inherent advantage of a university over an "Institute of Technology" was realized by only two schools, where sequenced humanities courses of upper class caliber were required. Elementary survey courses, frequently designed for large classes of untrained and uncritical lower class students and taught as an onerous duty by junior instructors, can hardly be stimulating for more mature upper class engineering students. If the situation is compounded by poor inter-faculty relations, chauvinism and lack of co-ordination, the results can only be disasterous.

Institutes of Technology face different problems and many have made a virtue out of the necessity of teaching a limited humanities program on a service basis. As Dr. Burdell [2] has pointed out, a small, closely integrated humanities program may have some definite advantages. Unfortunately, however, many small institutions have difficulty in attracting outstanding liberal arts instructors into surroundings where they may become intellectually isolated.

Frequently efforts by these Institutes have resulted only in a carefully arranged twelve-credit survey sequence in General Studies which includes Western Civilization and American Economic, Social and Political History. Whether such a course can be probing or whether it just appeals to intellectual dilletantism remains open to question.

Perhaps the weakest link in the present humanities structure arises from R.O.T.C. substitutions. The Grinter report objects to R.O.T.C. as an alternative to technical courses, but only "looks with apprehension" on R.O.T.C. substitution for the humanities. The students look at it another way: Any equating of Military Science with the humanities can only mean that the liberal arts courses are of secondary importance. Since as many as 35% of the upperclassmen may participate in Advanced R.O.T.C., the overall effectiveness of the humanities program may be seriously questioned.

Suggestions for a Revised Humanities Program

The above criticisms can only be met by a limited liberal arts program which balances the panoramic point of view of the general survey course with the intellectual demands of a specific discipline. Both are necessary: the broad point of view so that the student may gain perspective, and advanced work so that he can utilize the fruits of his experience in later life.

Discounting Freshman English, about fifteen per cent of the undergraduate curriculum should be devoted to humanistic-social studies to be in line with the Grinter report recommendations, or about 21 credit hours out of approximately 144 total credits required for graduation.

Most teachers would probably agree that at least six credit hours should be devoted to "Western Civilization" and that there should be at least one three credit Economics course (not Business Administration). Western Civilization gives the panoramic view; it includes social, cultural and political history. Within these time limitations it can only cover the high spots. But a discussion of selected topics from the "Golden Age of Athens" through "Reformation and Counter-Reformation" to the "Industrial Revolution and the Rise of Capitalism" will prob-

[2] E. S. Burdell, "The Humanistic-Social Studies in the Engineering Curricula," *J. of Eng. Ed.*, Vol. 45, No. 10, June 1955, pp. 747–752.

ably be more effective than a running account of dates and events.

Three credits of American History or Political Science should also be offered, either as an addition to the Western Civilization course, or preferably, as a separate offering.

The above suggestions account for twelve credit hours; there is room left for three additional three-credit humanistic-social courses. These should be fully sequenced free electives in one single field of endeavor. Economics, history, philosophy, literature, fine arts—any one of these or similar fields should be acceptable, provided the student is brought into close contact with a humanistic discipline. This requires that only one course may be of lower class level, the other two must be junior or senior courses. The student's interests should be the determining factor in the selection of the specific field; knowledge and enjoyment gained from a freely selected study sequence should be preferable to the smattering of ignorance provided by additional survey courses.[3]

Student motivation may still present difficulties, especially in a university where the engineering student is handicapped in competition with liberal arts majors with more definite interests—and with more time. This must be appreciated by the instructor; understanding coupled with high-quality teaching may not only develop student interest, but also utilize the scientific background of the engineering students to cross-fertilize the minds of the whole class.

Freshman English deserves special consideration. Frequently it is little more than a make-up course for inadequate high school training. While a majority of the students may well be subjected to a 3–4 credit course in Rhetoric and Composition, the good student deserves better treatment. Why not encourage him to pass a substantiating examination and to waive the Freshman English requirement? And then allow him either free time or, at least, an unrestricted elective. There should be a real incentive for proficiency in English; substitution of Advanced Literature for Rhetroic and Composition is hardly enough encouragement. A special safeguard can always be provided: Any student who fails to maintain acceptable standards in written presentation (as determined by liberal arts or engineering instructors) must enroll in a remedial, noncredit "Composition Work Shop" until his performance is judged to be satisfactory.

Finally, what about required courses in English Literature? It may be highly desirable to have engineers go through a condensed "Great Books" schedule to improve their cultural background, but most students are likely to revolt against this idea. Literature is probably the humanities course which faces the heaviest opposition: most classical works are far removed from the daily experience of engineering students, who find literature to be an indirect and cumbersome bridge to the understanding of ideas. As Dr. Davis [4] has pointed out, engineers are pragmatists who are likely to prefer Dreiser to Dryden and Shaw to Shakespeare. If literature must be taught, let it either be in terms of the student's daily experience, or disguise it effectively in the Western Civilization course where the stage can be properly set.

[3] While at the time of the survey (Dec. 1955) only two colleges required sequenced upper class humanities electives, a few other schools, including New York University, have since initiated a similar program.

[4] J. H. Davis, "An Administrator Takes a Look at General Studies for Engineers," *J. of Eng. Ed.*, Vol. 46, No. 2, Oct. 1955, pp. 109–114.

R.O.T.C. Substitutions

Students enroll in the Advanced R.O.T.C. course for two reasons: Additional subsistence funds and to become commissioned officers during their period of military service. For this advantage they should be expected to make some sacrifice. R.O.T.C. courses without substitutions will generally overload the program, and, therefore, a reasonable compromise will have to be sought.

Of the usual twelve credit hours of Advanced R.O.T.C., six should be taken as overload without allowance, three credits should be substituted for an engineering elective and three for a humanities course. Even with the tightening up of our present engineering curricula, three less credits of engineering should hardly make the difference between the qualified and the unqualified graduate. The other three humanities credits can be made up by selected summer reading on topics chosen jointly by the student and the instructor. The results of this reading should be submitted in a critical "Summer Essay" and also orally presented in the appropriate humanities course.

Conclusions

The program suggested above is just one possible avenue of attack; it can not cure all the ills of the present humanities offerings. It will present many difficulties, ranging from the requirements of new staff members to the mundane aspects of scheduling simultaneous elective classes.

But it can be done, as a few schools with the handicap of small service departments have already demonstrated. And if such a program has a chance to succeed in supplementing learning for apathy, of making engineers into citizens willing to assume the responsibility of intelligence, then it deserves a fair and impartial trial by a faculty of engineering and liberal arts teachers working in harmony to make it a success.

HEAT POWER NEWS & VIEWS

The first issue in the current series of *Heat Power News & Views*, published by the Mechanical Engineering Division of ASEE and edited by C. O. Anderson of North Dakota State College, was recently distributed to subscribers. The bulletin presented the very excellent article by Myron Tribus of the University of California which attracted favorable comment at the annual meeting in Cornell last June. Dr. Trybus' discussion of "Thermodynamics at the Graduate Level" is reproduced in full. Also presented in this issue is "How to Teach Thermodynamics Courses," by H. F. Mullikin of Montana State College. This paper offers some sound advice from an experienced teacher and administrator. *News & Views* is now available at the reduced rate of $1.00 for two years.

. . . . . YET-ITUDES

VIEWS AND NEWS CONTRIBUTED BY

The Young Engineering Teachers

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A HUMANITIES TEACHER LOOKS AT ENGINEERING EDUCATION

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In his *Politics* Aristotle says that the Spartans rightly thought the goods for which men contend are to be gained by virtue, but that they erred in valuing the goods more than the virtue by which they are gained. In early America, the Calvinists believed it was a positive sin to be profligate of time, talents, and resources, so that in discharging their duty to God they understandably became rich. It was then an easy step to the view that the real aim in life is wealth and that the same virtues are valuable but now for economic rather than for religious reasons.

This may suffice to demonstrate that men have never been immune from doing the right thing from the wrong motives and for the sake of mistaken ends. Herein lies a lesson for those of us concerned about the role of the humanities in engineering education.

Among the professional groups in America, the engineers are perhaps most vocal and insistent on the importance of humanities in education. Though the reasons for this concern are hardly ever clear, it is clear from much of the literature on the subject that the gains which engineers hope to appropriate through the humanities are not always consistent with the means that have been adopted. It is quite possible that we have here again an effort to do the right thing but for the wrong reasons, and in this instance such a mistake cannot help but lead to dissatisfaction with the results.

The engineer is like a man with a thousand keys to open ten thousand boxes and unleash more than ten thousand genies to satisfy his every desire. Behold! History brought to life through a bright glass window; conversation preserved on a thin strand of wire. Dinner from a transparent bag cooked in less time than it takes to set the table. The gods themselves, Hermes and Apollo, at your service.

What delights! What wonders! What a joy to be as the engineer, possessor of a thousand keys with which to preside over the birth of as many miracles. This is, in fact, an age in which our chief concern is that man should tyrannize over things. Each advance in technology is the acquisition of a new tool for our tyranny. This is now, and forever will be, the great contribution of engineering to our society—better things for better living, but mostly things.

Why of Interest?

How then, by even the wildest conjecture, can one suppose the humanities have any interest for the engineer? Can it be that the humanities constitute another key, another tool for man's role as tyrant over things? This is the view implicit in most of the literature on this subject.

There is a tendency to consider what tools the engineer needs at his disposal and then to ask what the humanities can offer toward the acquisition of these tools. The humanities are frequently understood as the additional indispensable knowledge without which man will be brought short in his efforts at more and more complete control of his surroundings. A study of the humanities is, therefore, thought to be essential to the development of engineers.

This way of thinking involves two subtle but very important mistakes. In the first place it prescribes for the humanities an end which they do not now, never have, and never can accept. If it is the concern of engineering that man should tyrannize over things, it is the aim of the humanities that men should tyrannize over themselves. If it is the hope of engineering that man should control nature, it is the hope of the humanities that men should control themselves. If it is the aim of engineering that men should understand and shape nature, it is the aim of the humanities that men should understand and shape themselves in accordance with ideals which they validate by their own conscious consent.

The humanities put forward no special claim to be useful as a tool for the engineer. Indeed, the fact is that as long as they are studied from the wrong motive, their benefits will be forever concealed. The student who expects the humanities to provide him with some immediately useful knowledge or skill will never discover their utility. He will seek instead to apply his knowledge, as he would in engineering, to matters external to himself, and hence the implications of the humanities for self-knowledge will escape him. This view is encouraged too by the teacher or administrator who tries to gain the confidence of his students by promising that the humanities can give them some special professional advantages. Such an appeal tends to defeat the ends for which the humanities more than any other inquiry are suited.

Indeed, like a lady of virtue, the study of humanities will forever conceal her beauties from the man who wants her for unacceptable reasons. To suppose that engineers ought to study humanities in order to avail themselves of a necessary tool to rule more successfully over things is to do the right thing for the wrong reasons. It is to mistakenly assume that knowledge of the humanities, like knowledge of engineering, is acceptable by virtue of the fact that it is useful for some end beyond man himself.

Knowledge or Questions?

This way of thinking obscures a second mistake, however. It also involves the view that the humanities constitute a body of knowledge. Admittedly this may seem to be an advance over the view of most students who seem to feel that the humanities is really a body of conjecture, but the fact is that we would be closer to a practical view if we were to say that the humanities is a body of questions. It may be that if they have any function in engineering education, the humanities aim not at providing the student with a body of knowledge but at equipping him with an array of questions.

Let us be perfectly frank, too, and

acknowledge that the issues of the humanities are often dead issues not only among engineering students but among men generally, and—shameful though it is—even among teachers of humanities. But if they are dead issues, there is a reason.

The liberal arts are liberal only to the extent that they have the capacity to free a man from the limits of his own time and his own society. It is within the province of the humanities, therefore, to bring into question the very goals of society which men in each age have found acceptable, not for the purpose of destroying those values, but to the end that men may be free to repudiate or embrace anew the ideas which they had hitherto accepted blindly as the dictates of society and tradition.

This means that it is within the limits of the humanities to bring into question the very values upon which engineering itself rests its claim to our acceptance. Knowledge of engineering is instrumental knowledge, and as such is of value only as long as men value the ends for which it is the proper instrument. But those final goals which validate the engineering enterprise can be repudiated. To bring such matters into question successfully is deeply disturbing. It has the pernicious effect of setting students adrift, free to accept again or to reject the values which had heretofore made their activity meaningful.

The problems of the humanities clearly are problems which can go unanswered by me, but cannot go unanswered by society; so that if I do not take my own stand, I shall necessarily take the stand of my society. Because this is the case, it is also the case that the issues of the humanities are solved for most of our students by their society and therefore are dead issues which can be laid aside as the playthings of the pedant. Let there be no mistake, then: it is of the greatest practical concern that in engineering education we conceive of the humanities not simply as a body of knowledge to be mastered, but as a body of questions to be made real.

Philosophy

When an engineering student asks "Why should I study philosophy?" his question does not arise solely because he sees nothing practical that can issue from the study. The point is that the question can only stem from the mind of a person for whom the issues of the humanities are dead. The only honest way to answer, therefore, is to raise the humanistic questions in such a way that they demand an answer, and this requires that we look upon the humanities first and fundamentally as a body of questions and not as a body of knowledge.

We can offer engineering students a variety of intellectual answers to a great many humanistic questions and they will learn them. But the whole enterprise is pointless unless in the process the questions are made living and real. Of what avail is it for a student to read Marcus Aurelius unless the problem for the stoic is a problem for the student? The humanities can be interesting, amusing, intriguing, fascinating, and exciting; they can also be shocking and disturbing, but they are meaningful only to that person for whom the humanistic questions are a matter of concern.

There is yet another reason why the humanities should be approached as a body of questions. The prevailing intellectual climate, to which scientists and enginers have contributed, embraces the view that unanswerable questions are not worth asking—indeed, are not questions at all. And the opinion is very much abroad that the questions of the humanities are

unanswerable, in fact are matters of idle speculation. This is a mistaken view.

These questions are not unanswerable, though it is true that we cannot always specify what is the right answer. Moreover, this is no scandal. It is not even a matter of regret that in the humanities we cannot always specify which views are mistaken. This is in fact the chief glory of the humanities, for human history fairly shrieks its testimony that there are many answers and that they make a difference. This in itself is sufficient to reveal the great variety of terms on which life can be lived and the fact that man is free to choose what he shall believe and therefore is in some measure responsible for what he shall become.

This is the miracle the humanities disclose. To reveal this miracle to students is to display for them the awful responsibility of defining their own commitments and at the same time to demonstrate that in so doing, within the limits society will allow, men have it within their power to constitute themselves the kind of human beings they will be. It is in this way that the issues of the humanities become living, pressing problems which cry out for answers. What shall I believe? This is a question which lies at the center of the humanistic studies.

Enginering educators seem to feel that engineers should be exposed to the humanities because it will make them better engineers. This is to do the right thing for the wrong reason. Nothing could interest a humanities teacher less. Unlike engineering, the humanities aim at nothing beyond the nurture of the human being himself. If the humanities are approached in this way it is more likely that engineers will be the better men for having had the experience and will incidentally, but only incidentally, be better engineers.

WILLIAM OGDEN WILEY

William Ogden Wiley, book publisher and Honorary Chairman of the Board of John Wiley & Sons, Inc., died in his New York City home on January 15, 1958, at the age of 95.

A friend of many leading engineers and scientists, whose books he published, Wiley became an honorary member of ASEE in 1904. The organization was then known as the Society for the Promotion of Engineering Education. Mr. Wiley served as treasurer of the Society from 1907 to 1942. He was also a member of the American Chemical Society, the American Forestry Association, and the American Society of Mechanical Engineers.

A graduate of Columbia College, Mr. Wiley acquired a master's degree at Columbia before joining, in 1890, the publishing firm founded by his grandfather, Charles Wiley. He became secretary of the company in 1904, vice president in 1924, president in 1925, and chairman of the board in 1941, holding the latter position until his retirement in 1956. His long publishing career closely associated him with engineers and advances in the engineering profession.

NEW MEMBERS OF ASEE

As of January 13, 1958

ADASHKO, J. GEORGE, Assistant Professor, College of the City of New York, New York, N. Y. William T. Hunt, Jr., Robert Stein. Divisional Interest: E. E.; Phys.

ALHASHMI, HAMEED AHMED, Lecturer in Electrical Engineering, Aligarh University, India. F. C. Lindvall, W. Leighton Collins. Divisional Interest: E. E.; Admin., Educa.

ANDERSON, WILLIAM L., Assistant Professor of Civil Engineering, University of South Carolina, Columbia, S. C. Harold Flinsch, B. L. Baker.

BLIZARD, WARREN E., Instructor of Mechanical Engineering, North Carolina State College, Raleigh, N. C. J. S. Doolittle, J. F. Lee. Divisional Interest: M. E.

BOURGALT, ROY F., Associate Professor of Mechanical Engineering, Worcester Polytechnic Institute, Worcester, Mass. Donald N. Zwiep, B. L. Wellman. Divisional Interest: Min. Tech., Metal.; M. E.

BURSTEIN, SAMUEL Z., Teaching Fellow in Mechanical Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. J. Bartels, Charles Oergel.

CHASTON, A. NORTON, Instructor in Electrical Engineering, Brigham Young University, Provo, Utah. John N. Cannon, Charles N. Gardner. Divisional Interest: E. E.; Math.

DEWITT, DAVID P., Instructor in Mechanical Engineering, Duke University, Durham, N. C. Edward K. Kraybill, Harry A. Owen, Jr. Divisional Interest: M. E.; Math.

DOUGLASS, MATTHEW M., Instructor in Civil Engineering, Howard University, Washington, D. C. Raymond M. Jones, Addison E. Richmond.

DUNCAN, RICHARD H., Associate Professor of Electrical Engineering, New Mexico College of Agriculture and Mechanic Arts, State College, N. Mex. M. A. Thomas, A. M. Lukens. Divisional interest: E. E.; Phys.

ECKEL, JOHN F., Head of Metallurgical Engineering Department, Virginia Polytechnic Institute, Blacksburg, Va. J. W. Whittemore, W. Leighton Collins. Divisional Interest: Admin., Educa., Metal. Eng.; Min. Tech., Metal.

FLETCHER, LEONARD J., Vice President, Caterpillar Tractor Company (Retired), Carmel, Calif. W. L. Everitt, H. H. Jordan. Divisional Interest: Admin., Indus., Educa. and Train.; Agr. Eng.

GARDNER, WILLIAM H. JR., Associate Professor of Civil Engineering, Duke University, Durham, N. C. Edward K. Kraybill, Harry A. Owen, Jr. Divisional Interest: C. E.

GRAHAM, JAMES D., Assistant Professor of Electrical Engineering, Marquette University, Milwaukee, Wisc. A. Bernard Drought, Raymond J. Kipp. Divisional Interest: E. E.

HALL, DANIEL R. A., Assistant to the President, Administration Dept., Newark College of Engineering, Newark, N. J. C. H. Stephans, Robert Kiehl. Divisional Interest: Admin., Educa.; Human.-Social Studies, Econ. & Hist.

HAMILTON, MAURICE E., Instructor, Purdue University, West Lafayette, Ind. J. N. Arnold, K. E. Botkin.

HAMMER, SANFORD S., Instructor, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. J. Bartels, Charles Oergel.

HARP, JAMES F., Instructor in Engineering Mechanics, University of Arkansas, Fayetteville, Ark. R. C. Wray, J. R. Bissett.

HOLLAND, CHARLES D., Associate Professor of Chemical Engineering, A. & M. College of Texas, College Station, Tex. J. G. McGuire, R. M. Wingren.

HUMPHERYS, DEVERL S., Instructor in Electrical Engineering, Brigham Young University, Provo, Utah. John N. Cannon, Charles N. Gardner. Divisional Interest: E. E.; Math.

HYDE, A. P. S., Instructor in Civil Engineering, Detroit Institute of Technology, Detroit, Mich. E. A. Lucitte, L. L. Henry.

JOHNSON, MALCOLM C., JR., Editor, College Department, McGraw-Hill Book

Company, New York, N. Y. K. I. Zeigler, John W. Taylor. Divisional Interest: C. E.

KETTER, ROBERT L., Research Assistant Professor of Civil Engineering, Lehigh University, Bethlehem, Pa. C. D. Jensen, W. J. Eney. Divisional Interest: C. E.; Mech. & Mat'ls.

KILGORE, HERBERT H., Mfg. Representative, Educational Department, Keuffel and Esser Company, Stone Mountain, Ga. W. L. Collins, F. C. Lindvall. Divisional Interest: Human.-Social Studies, Hist.; Math.

KNIGHT, RICHARD, B., Professor of Mechanical Engineering, North Carolina State College, Raleigh, N. C. J. S. Doolittle, J. F. Lee. Divisional Interest: M. E.; Aeronautics & Aero. Eng.

LEWIS, RUSSELL M., Instructor in Civil Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. R. K. Palmer, H. O. Sharp. Divisional Interest: C. E.; Arch. Eng.

MORRISEY, JOHN A., Supervisory Instructor and Director of Evening School, Capitol Radio Engineering Institute, Inc., Washington, D. C. L. M. Upchurch, Jr., J. P. Evans. Divisional Interest: Tech. Inst.; Admin., Educa., Electronics.

MUGA, BRUCE J., Instructor in Civil Engineering, Montana State College, Bozeman, Mont. G. J. Herman, E. R. Dodge.

MCKEEL, JAMES T., JR., Instructor in Electrical Engineering, Duke University, Durham, N. C. E. K. Kraybill, H. H. Owen, Jr. Divisional Interest: E. E.; Math.

NUTT, MERLE C., Assistant Professor of Engineering, Arizona State College, Tempe, Ariz. G. C. Beakley, L. P. Thompson. Divisional Interest: M. E.; Ind. Eng.

PARKER, BLAINE F., Associate Professor of Agricultural Engineering, University of Kentucky, Lexington, Ky. D. T. Kinard, E. R. Young. Divisional Interest: Agr. Eng.

PELAN, BYRON J., Assistant Professor of Mechanical Engineering, Rutgers University, New Brunswick, N. J. Samuel Sailer, C. R. G. Dougherty. Divisional Interest: M. E.; Ind. Eng.

PREATOR, FREDERICK, Professor and Head of Department of Tool Engineering, Utah State University, Logan, Utah. Reinstating Lapsed Membership. Divisional Interest: Gen. Eng.; Ind. Eng.

PRIDE, JAMES M., Special Assistant to Chief of Training and Development Division, Office of Civilian Personnel, Department of the Army, Washington 25, D. C. J. G. Wohlford, W. H. Merchant.

RANGEL, FREDERICO, Director of Campanha Nacional de Aperfeicoamento de Pessoal de Nivel Superior (CAPES), Rio de Janeiro, Brazil. F. C. Lindvall, W. L. Collins.

RIESE, RUSSELL L., Professor of Engineering, Arizona State College, Tempe, Ariz. G. C. Beakley, L. P. Thompson.

RINGELSPAUGH, JOHN H., Instructor in Apprentice Division, Henry Ford Community College, Dearborn, Mich. H. E. Hedinger, T. A. Lind. Divisional Interest: Eng. Draw.; Admin., Ind., Apprentice Training.

ROGERS, E. DE LANCEY, Instructor in Engineering Physics, City College of San Francisco, San Francisco, Calif. C. J. Aggeler, J. F. Schon. Divisional Interest: E. E.; Communica. & Electronics; Phys.

SACHS, JEROME M., Assistant Dean in Charge, Chicago City Junior College, Chicago, Ill. W. L. Collins, F. C. Lindvall. Divisional Interest: Admin., Educa., Math.; Tech. Inst.

SARKEES, YAZBECK T., Assistant Professor of Electrical Engineering, University of Buffalo, Buffalo, N. Y. D. H. Stellrecht, Frederic P. Fischer. Divisional Interest: E. E.; Math.

SHORT, WILLIAM C., Engineering Manpower Control Representative, Lockheed Aircraft Corporation, Engineering Dept., Van Nuys, Calif. H. C. Maechler, Jack Kadushin. Divisional Interest: Admin., Ind.

SNOBLIN, KENNETH A., Chairman, Engineering Drawing, Lawrence Institute of Technology, Detroit, Mich. M. M. Ryan, J. W. Hobson. Divisional Interest: Eng. Draw., Math.

SPRENKLE, RAYMOND EYLER, Director of Education, Bailey Meter Company, East Cleveland, O. E. J. Lindahl, W.

L. Collins. Divisional Interest: Admin., Ind.; M. E.

STEPHENSON, HAROLD P., Associate Professor of Mechanical Engineering, Duke University, College of Engineering, Durham, N. C. E. K. Kraybill, H. A. Owen, Jr. Divisional Interest: M. E.; Phys.

SULLENBERGER, ROBERT A., Instructor in Tool Engineering, Utah State University, Logan, Utah. E. Rich, D. F. Peterson. Divisional Interest: Gen. Eng.; Ind. Eng.

TAYLOR, JAMES I., Instructor in Civil Engineering, Fenn College, Cleveland, O. Michael Shuga, D. L. Penney. Divisional Interest: C. E.; Mech. & Mat'ls.

VAN BENSCHOTEN, RICHARD P., Instructor in Mechanical Engineering, Rutgers University, New Brunswick, N. J. Samuel Sailor, C. R. G. Dougherty.

VILAS, JOHN M., Instructor in Electrical Engineering, Duke University, Durham, N. C. E. K. Kraybill, H. A. Owen, Jr. Divisional Interest: E. E.

WILSON, NYAL E., Instructor in Engineering Drawing, Syracuse University, Syracuse, N. Y. G. N. Page, G. W. Walsh, Jr. Divisional Interest: C. E.; Eng. Draw.

YOUNG, GEORGE A., Associate Professor of Civil Engineering, University of Illinois, Urbana, Ill. Ellis Danner, David Day.

50 new members
501 new members this year (previously)

551 new members this fiscal year

AIR POLLUTION AND ITS CONTROL

The Engineer's Joint Council has issued the following statement of policy as to the engineer's function in the control of air pollution:

"Engineering involves directing the forces of nature and the activities of man to his own use, convenience and welfare. In view of air pollution's causes and effects, and the technical nature of its control, the engineering profession is qualified and is duty bound to contribute substantially to the control of air pollution.

Engineers are involved, through research, development, design, construction, installation, operation and maintenance, in activities that bring into being man-made sources of air pollution. Engineers have already made substantial contributions to the solution of air pollution problems by application of technical knowledge. Many of these contributions have resulted from efforts to utilize fuels and raw materials more effectively, while others have come from efforts specifically directed to minimizing air pollution nuisances and hazards.

Other professional disciplines are contributing to effective air pollution control in many fields; including agriculture, biology, government service, law, medicine, meteorology, politics, public health, science, and soil conservation.

The engineering profession is prepared to discharge its responsibilities in the physical control of air pollution by full participation with other professional disciplines, in establishing and effecting sound policies of control."

TEACHING POSITIONS AVAILABLE

ASSISTANT OR ASSOCIATE PROfessor—To teach undergraduate courses in Aeronautical Engineering and graduate courses in propulsion, instrumentation, or structures. Industrial and teaching experience desired. Opportunities available for further graduate study, consulting, and research. Send resume of education and experience to: Chairman, Department of Aeronautical Engineering, Wayne State Univ., Detroit 2, Mich.

ELECTRICAL ENGINEERS. ACAdemic position combining teaching and fundamental experimental research. Assistant Professorship for recent Ph.D. or equivalent background, higher rank in accord with qualifications. Write D. C. Drucker, Chariman, Division of Engineering, Brown University, Providence 12, Rhode Island.

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MECHANICAL ENGINEERING—ASsistant or Associate Professor to teach thermodynamics, vibrations, and mechanical engineering laboratory. M.S. degree required, Ph.D. desirable. Rank and salary commensurate with qualifications. Position available March 17 or September 1, 1958. Write E. R. Stensaas, Head, Department of Mechanical Engineering, South Dakota School of Mines, Rapid City, South Dakota.

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